SD
1
J8

JOURNAL OF MAMMALOGY

VOL. 37 AUGUST 1956 NO. 3

UNIVERSITY
OF MICHIGAN
SEP 21 1956
FORESTRY
LIBRARY

AMERICAN SOCIETY OF MAMMALOGISTS

The American Society of Mammalogists

Founded April 3, 1919

Incorporated April 29, 1920

Officers

WILLIAM B. DAVIS, *President*
ROBERT T. ORR, STEPHEN D. DURRANT, *Vice-Presidents*
RANDOLPH L. PETERSON, *Recording Secretary*
BRYAN P. GLASS, *Corresponding Secretary*
CAROLINE A. HEPPENSTALL, *Treasurer*
RICHARD H. MANVILLE, *Editor*
ROLLIN H. BAKER, KENNETH L. DUKE, PHILIP L. WRIGHT, *Associate Editors*

Additional Directors

1956–1958	1955–1957
W. ROBERT EADIE	VIOLA S. SCHANTZ
DONALD F. HOFFMEISTER	EMMET T. HOOPER
ROLLIN H. BAKER	J. KENNETH DOUTT
BERNARDO VILLA-R	OLIVER P. PEARSON
ANTOON DE VOS	WILLIAM V. MAYER

Past Presidents

HAROLD E. ANTHONY	E. RAYMOND HALL
H. H. T. JACKSON	REMINGTON KELLOGG
WALTER P. TAYLOR	TRACY I. STORER
A. BRAZIER HOWELL	WILLIAM J. HAMILTON, JR.
WILLIAM H. BURT	

Trustees

STEPHEN S. GREGORY, JR. (1957) WILLIAM P. HARRIS, JR. (1959) D. DWIGHT DAVIS (1958)

Standing Committees 1956–1957

Bibliography: David H. Johnson, *Chairman*. Claude W. Hibbard, Henry W. Setzer, Richard G. Van Gelder, Charles P. Lyman, James S. Findley.

Conservation of Land Mammals: William O. Pruitt, *Chairman*. Helmut K. Buechner, Jr., Antoon de Vos, J. Knox Jones, Jr., John Wood.

Editorial: Richard H. Manville, *Chairman*. Rollin H. Baker, Kenneth L. Duke, Philip L. Wright.

Honoraria for Graduate Students: Stephen D. Durrant, *Chairman*. Robert T. Orr, Frederick S. Barkalow, Jr.

Index of Journal of Mammalogy: Viola S. Schantz, *Chairman*. Charles O. Handley, Jr., David H. Johnson, Henry W. Setzer.

Marine Mammals: Robert T. Orr, *Chairman*. H. Dean Fisher, Raymond M. Gilmore, Gordon Gunter, Victor B. Scheffer, Joseph C. Moore.

Membership: Albert R. Shadle, *Chairman*. Randolph L. Peterson, Arthur Svihla, Willard D. Klimstra, Kenneth L. Duke, William V. Mayer.

Nomenclature: E. Raymond Hall, *Chairman*. Donald F. Hoffmeister, Philip Hershkovitz, Charles O. Handley, Jr., Richard G. Van Gelder.

Resolutions: Keith R. Kelson, *Chairman*. Emmet T. Hooper, William V. Mayer, Stephen D. Durrant, George C. Rinker.

The American Society of Mammalogists is an affiliate of the A. A. A. S., the A. I. B. S., and the National Research Council, and is an exchange member of the Nature Conservancy.

The Journal of Mammalogy

Journal of Mammalogy is published quarterly by the American Society of Mammalogists, Mt. Royal and Guilford Aves., Baltimore 2, Md.

Persons actively interested in mammalogy may become members of the Society upon nomination, payment of dues, and election. Applications for membership may be obtained from the corresponding secretary. The Journal of Mammalogy is sent free to all members of the American Society of Mammalogists not in arrears for dues ($4.00).

Subscription rates are $6.00 per year; single numbers of the Journal are $1.50 each unless otherwise advertised on cover page 3.

Nominations and dues for membership, dues for subscriptions, changes of addresses, orders for back numbers and the two bound indexes, requests for missing numbers, and applications for advertising rates should be addressed to the Corresponding Secretary, Bryan P. Glass, Department of Zoology, Oklahoma A & M College, Stillwater, Oklahoma.

Publications for inclusion in the bibliography of mammalogical literature, section on "Recent Literature," should be sent to David H. Johnson, Division of Mammals, U. S. National Museum, Washington, D. C.

Manuscripts for publication, books for review, and papers for special comment should be sent to the Chairman of the Editorial Committee, Richard H. Manville, 151 Ossining Road, Pleasantville, New York.

Entered as second class matter, November 22, 1919, at the Postoffice, Baltimore, Md., under the act of March 3, 1879.

Made in United States of America

JOURNAL OF MAMMALOGY

Published Quarterly by the American Society of Mammalogists

VOL. 37 AUGUST —, 1956 No. 3

OBSERVATIONS OF CAPTIVE AND WILD CETACEANS

BY DAVID H. BROWN AND KENNETH S. NORRIS

During the first months of operation (March, 1954 to Sept. 1955) of the new oceanarium, Marineland of the Pacific, we have had numerous opportunities to observe the dolphins and porpoises of California waters. In addition, we have recorded the behavior of captive Atlantic bottlenose dolphins (*Tursiops truncatus*). Many members of the staff at Marineland have assisted in making these observations. We are particularly grateful to Frank Brocato, Captain of the collecting vessel, *Geronimo*, and his assistant, Frank Calandrino, for their help in compiling the field observations. We wish to thank Dr. Leonard L. Mortimer D.V.M., for his assistance and suggestions during treatment of captive animals. Dr. Raymond Gilmore has given us much assistance and has critically reviewed the manuscript.

We follow Norman and Fraser (1940) in their definition of the terms *porpoise* and *dolphin*; *porpoise* refers to members of the Delphinidae which are small, beakless, and with triangular dorsal fins and tricuspid teeth. *Dolphin* is used for the remainder of the family, except those larger forms dignified by the name, *whale*.

PACIFIC WHITE-SIDED DOLPHIN

This species (*Lagenorhynchus obliquidens* Gill, Pl. I, Top) and the common dolphin (*Delphinus bairdi*) have been observed many times more than these data indicate, particularly during the months before Marineland of the Pacific was completed. These observations serve to strengthen the conclusions we draw here.

Seasonal movements.—The Pacific white-sided dolphin is probably the most common cetacean species in southern California waters. Schools scattered over areas as large as four square miles that numbered an estimated 1000 animals have been sighted in the channel between Santa Catalina Island and the mainland. Diffuse schools such as these are usually engaged in feeding and consist of small widely separated bands of animals. When the species is not feeding, the schools become much more compact.

Our records indicate that this dolphin frequents near-shore waters during winter and spring months, and moves offshore in summer and fall. Our earliest near-shore winter record is for December 21, 1954, and our latest spring records are June 26, 1954, and the following year on May 18, 1955. Porpoise schools, probably *Lagenorhynchus* and *Delphinus* have been reported by various sources from the outer coast of San Clemente Island, the Clemente Channel (between San Clemente Island and Santa Catalina Island), Osborn Bank, the area around San Nicolas Island, and the Anacapa- Santa Cruz Island area, during summer and fall. We have captured *Lagenorhynchus* in the vicinity of San Nicolas Island in July.

This exodus of the species from near-shore areas is seemingly dependent upon movements of its food supply. The anchovy, *Engraulis mordax*, occurs in large schools along the California coast throughout the year. In winter and spring, very large schools are common in fairly deep water, within a few miles of shore. In the Catalina Channel, major concentrations occur in the vicinity of the 100 fathom curve on both sides of the channel. *Lagenorhynchus* has been found feeding extensively on these fish during these colder months. In summer and fall the anchovies move closer to shore. The summer bait fishery for *Engraulis* at San Pedro, is concentrated inside the Los Angeles Harbor breakwater. The open-water-loving Pacific white-sided dolphin does not venture into such restricted waters. As a result it moves out to sea, shifting from a principal food of anchovies to the offshore schooling fish, the saury, (*Cololabis saira*). This conclusion is based only on observations of feeding schools and not upon stomach analysis. Future investigation may show that certain populations of *Lagenorhynchus* continue to follow the anchovy throughout the seasons; for example on the extensive shallows near Santa Cruz Island.

TABLE 1.—*Locality records for Lagenorhynchus obliquidens*

Locality	No. animals	Growth stage	Date
8 mi. S. San Pedro Lighthouse, Catalina Channel, Calif.	100	Adults & young	June 6, 1954
12 mi. S. San Pedro Lighthouse, Catalina Channel, Calif.	1	Adult	June 8, 1954
12 mi. S. San Pedro Lighthouse, Catalina Channel, Calif.	2	Adults	June 10, 1954
San Nicolas Island	Large school		Sept. 4, 1954
2 mi. S. Dana Point, Orange County, Calif.	12	Adults	Dec. 21, 1954
1 mi. SW Dana Point, Orange County, Calif.	5	Adults	Dec. 22, 1954
14 Mile Bank, between Newport Beach and Santa Catalina Island	24 Approx.	Adults	Jan. 12, 1955
10 mi. SE San Pedro Lighthouse	3	Adults	Jan. 25, 1955
5 mi. S. Pt. Vicente, Catalina Channel, Calif.	500 Approx.	Adults	Feb. 4, 1955
3–5 mi. S. Pt. Vicente, Catalina Channel, Calif.	500 Approx.	Adults	Feb. 5, 1955
8 mi. S. San Pedro Lighthouse, Catalina Channel, Calif.	50 Approx.	Adults	Feb. 9, 1955
8–10 mi. S. San Pedro Lighthouse, Catalina Channel, Calif.	1000 Approx.	Adults	Feb. 11, 1955
9 mi. SW San Pedro Lighthouse, Catalina Channel, Calif.	Large school, very diffuse		Mar. 19, 1955
6 mi. NE White's Landing, Santa Catalina Island, Calif.	120 Approx.	Adults	Apr. 13, 1955
7 mi. N. West End Santa Catalina Island, Calif.	200	Adults	Apr. 19, 1955
6 mi. S. San Pedro Lighthouse, Catalina Channel, Calif.	1000 Approx.	Adults	May 4, 1955
2 mi. S. Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	400 Approx.	Adults	May 6, 1955
10 mi. S. Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	12	Adults	May 18, 1955
6 mi. S. Pt. Mugu, Ventura Co., Calif.	4	Adults	Aug. 30, 1955

Feeding.—These beautiful cetaceans have been seen feeding upon anchovy schools many times, and upon sauries. At such times the dolphins are scattered into small groups, milling among the frightened schools of fish. They are usually accompanied by flocks of gulls and often, California sea lions (*Zalophus californianus*). We have also seen adult sea elephants (*Mirounga angustirostris*) in such aggregations on three occasions. When we have passed over feeding schools of the Pacific white-sided dolphin, the water has sometimes been filled with glittering anchovy scales. Feeding *Lagenorhynchus* seldom can be diverted from their feeding to play around the bow of a passing vessel—unlike *Delphinus bairdi*, which seems always ready to sport in the bow wave, even if it has just been actively feeding. Very often, *Lagenorhynchus* is found in mixed schools with *Delphinus*. No tendencies toward dominance orders were noted except that when both species were running the bow together, the *Lagenorhynchus* seemed less inclined to surface near the ship.

On June 6, 1954, an adult female weighing 190 pounds and measuring six feet even, from the notch of the tail flukes to the tip of the rostrum, was harpooned, eight miles due south of San Pedro Lighthouse, Los Angeles County, California. The stomach contents were examined. The large pointed first stomach chamber was filled with partially digested anchovies, fish bones, otoliths, fish scales, fish eye lenses and one blanched but otherwise undigested squid, *Loligo opalescens*, which with the sardine, *Sardinops caerulea*, are probably important items also in the diet of this dolphin.

Schooling behavior.—When a specimen of *Lagenorhynchus* is captured, the other members of its school swim rapidly around it, swimming over and under the line that restrains it, brushing against the captive. Many individuals will swim along with the injured and tethered animal as it is taken into the skiff and not until it has disappeared on board do they disperse. A previous report of this sort of behavior has been made by Hubbs (1953) for a harpooned animal. This behavior is unlike that of *Delphinus bairdi*, whose associates leave a captured animal as soon as it begins to struggle and slow down.

Young.—On June 6, 1954, we followed a mixed school of adults and young of *Lagenorhynchus*, eight miles due south of San Pedro Breakwater. Each young animal was an estimated three feet long and 75 lbs. in weight. Each young animal kept in perfect formation with an adult, staying within inches of its side as they swam along.

On June 26, 1954, a school of 40 small *Lagenorhynchus* was sighted, eight miles south of Newport, Orange County, California. These animals were unaccompanied by adults. Each weighed an estimated 70 pounds. Neither the young alone, nor the adults with young, could be closely approached by the boat.

Albinism.—Cases that probably represent albino *Lagenorhynchus* have been noted. On April 13, 1955, a mixed school of 200 *Delphinus* and *Lagenorhynchus* (approximately ⅓ *Lagenorhynchus* and ⅔ *Delphinus*) was encountered six miles NE of White's Landing, Santa Catalina Island, California. A large adult *Lagenorhynchus*, with a strongly hooked dorsal fin, was noted in the school. It was unpigmented except for a mottled gray area running dorsally from the snout onto the tail stock. The remainder of the animal was snowy white. It swam under the bow for some time and surfaced about twelve times before it disappeared. The whole school swam rapidly away, passing through an extensive school of anchovies without stopping. On May 4, 1955, a less distinctively marked animal was observed six miles south of San Pedro Lighthouse. This *Lagenorhynchus* had a markedly faded pattern and its dorsal surface was covered with dirty gray spots.

R. G. Murdoch, Captain of the trawler, *Grace H.*, of Morro Bay, California, reports that on July 12, 1954, a school of dolphins ran along the bow of his vessel while he was fishing on 176 fathom Bank, between San Martin Island and Guadalupe Island, Baja California, Mexico. He was amazed to see that one of these animals was snow white except for small black eyebrows. His description makes it seem likely that this animal was *Lagenorhynchus obliquidens*.

Size and proportion.—When fully grown this animal attains a total length of at least seven feet. The largest specimen measured by our collectors was six feet, 11¾ inches in total length. A considerably larger animal, an adult male, was captured on May 18, 1955, in the middle of the Catalina Channel. Because keeping male dolphins in captivity presents

serious problems, the animal was released, unfortunately without being measured. Its weight was estimated at 380 pounds.

Adults can, in general, be distinguished from subadults by observing the degree of curvature of the posterior edge of the dorsal fin. This curvature seems considerably more pronounced in the older, larger animals, the distinct hook-like development being quite unmistakable. Both males and females possess this hooked dorsal fin.

Capture methods.—The first few *Lagenorhynchus* taken by our collectors were obtained with a device used originally by Indians to catch Pacific salmon. This consisted of a stout pole, about 12 feet long, at one end of which three 11/0 Pflueger-Sobey barbless hooks were placed into longitudinal slots and held in place with strips of adhesive tape. These hooks were attached to a stout manilla line.

Our collector selected a specimen, as the dolphins ran the bow of the boat. He quickly thrust with the pole and was invariably successful in imbedding one of the hooks into the animal's back or sides. The instant the hook found its mark, all three hooks disengaged from the pole, leaving the animal firmly fastened to the line. All the animals except three, caught by this method, died as a result of the injury inflicted by the hook. We have since discarded the hook method in favor of a "mercy harpoon" developed by our chief collector, which does not harm the animals during capture.

Hooked specimens immediately rush off, often taking out as much as 200 yards of line. The collectors follow down the line in a skiff. One man then seizes the dolphin by its tail stock and the animal is unceremoniously rolled over the side onto a foam rubber mattress. It is remarkable that these large and very powerful animals almost invariably cease struggling completely once they are seized by the tail. On deck they generally rest quietly, blowing intermittently. This was so with both *Delphinus* and *Lagenorhynchus*. These dolphins are deeply frightened by their capture. One adult *Lagenorhynchus* died shortly after capture, apparently from shock, as the animal was taken without injury.

Treatment of captives.—Hooked animals were given immediate treatment, once they were placed in deck. The hook, after penetrating the blubber and muscle tissue, would invariably turn and protrude through the back or side some two inches from the point of entry. This caused a U-shaped lesion. The wound was cleansed with sulfamethazine and plugged with sterile gauze. Rather profuse hemorrhaging occurred in the majority of cases. A cauterizing agent, iron subsulfide, was used to stop the flow of blood. As an additional precaution, 600,000 units of procaine penicillin in aqueous suspension were injected intramuscularly into the tail stock.

These animals later developed abcesses in their wounds, probably as a result of the poor circulation in the blubber.

It was necessary therefore to treat these animals each day for several weeks. The treatment consisted of opening and cleaning the abcess pocket with glycerite of hydrogen peroxide and an antibiotic solution containing nitro-furazone. After all evidence of discharge was removed the cavity was filled with erythromycin jelly and plugged with gauze. The animal was then given an injection of penicillin and released.

Dolphins rapidly become overheated when out of water. Much care has to be taken therefore, to make sure the captives remain cool. Each animal is protected with blankets and sprayed constantly with sea water (Pl. I, Bottom).

During the early stages of construction of Marineland of the Pacific, holding facilities were inadequate and we experienced much difficulty in keeping captive dolphins. The problem was complicated by the injury inflicted on early captives, by poor water supply and by leaky tanks. At one time we were forced to house our animals in a tank filled with fresh water. This caused the epidermis of the dolphins to degenerate into a blackish-gray paste-like substance, which rubbed off easily when the animals were captured for their regular injections of penicillin and vitamins. When these animals were returned to sea water, quantities of pasty material sloughed off, revealing healthy skin beneath.

Protective behavior.—Several of our captives died, either as a result of their injuries or of starvation. Sometimes all attempts to induce a captive to feed, either on live anchovies or

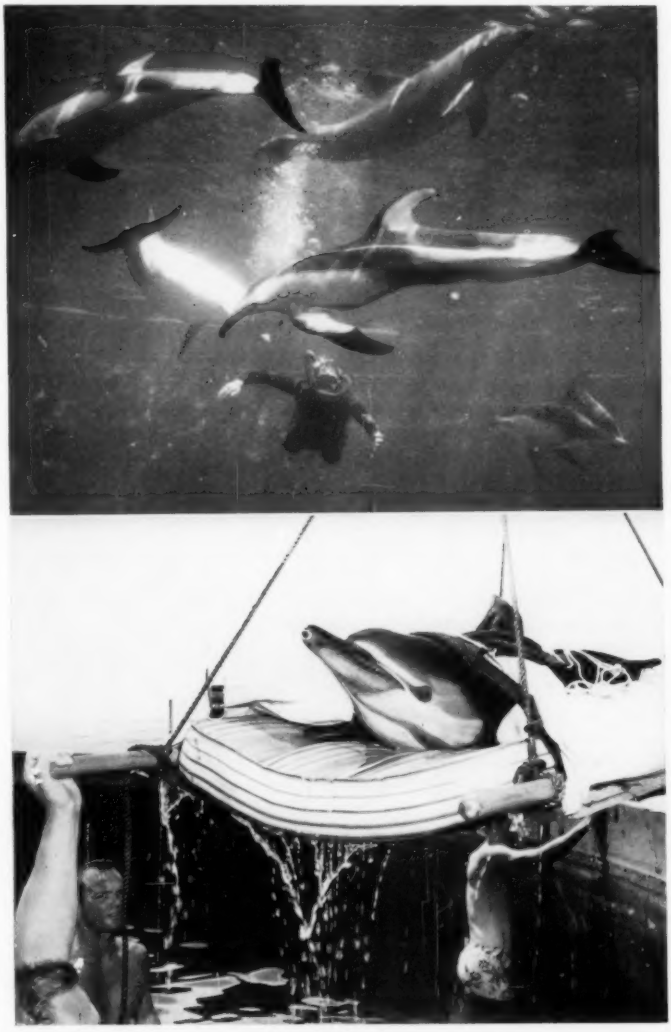


PLATE I

TOP: Captive *Lagenorhynchus obliquidens*, in company with *Tursiops truncatus*, in the circular tank at Marineland of the Pacific.

BOTTOM: Transporting a specimen of *Delphinus bairdi*. Photo by William Eccles.

dead fish, would fail. Death from starvation would ensue within 7–10 days. In an adequate tank uninjured animals usually begin to feed in a very short time.

The behavior of other dolphins in relation to these distressed animals is very interesting. The behavior seems similar to that reported for *Tursiops gilli*, where dead young were held out of water for long periods by the mother (Hubbs, 1953) and for *Tursiops truncatus* (McBride and Hebb, 1948, Moore, 1953).

One wounded female *Lagenorhynchus*, being held in a 35-foot circular cement tank, began showing signs of distress. She began to circle more slowly in the tank, surfacing with difficulty to breathe. A vigorous adult male *Lagenorhynchus* shortly took up station under her, sometimes swimming on his back directly beneath her, and, as nearly as we could tell, nudging her toward the surface from time to time. His intervals of apnea became much longer than usual. He turned over, returned to the surface, breathed and then quickly took up station under the female again as she circled. This behavior was observed for two days prior to the female's death.

On May 27, 1955, an adult male *Lagenorhynchus* died in the display tank from shock induced by the attacks of captive male *Tursiops truncatus*. The animal sank to the bottom of the tank. An adult female *Tursiops*, named Mabel, swam down to the bottom inspecting the stricken animal. She then forced her snout under his body and pushed upward so violently that her flexible neck was bent strongly downward. She was unable to move the prostrate animal. She made two such attempts before leaving the *Lagenorhynchus*. Another case in which *Delphinus bairdi* exhibited similar behavior is discussed with that species. Perhaps these instances and those presented by McBride and Hebb (*loc. cit.*) Hubbs (*loc. cit.*) and Moore (*loc. cit.*) lend some credence to the oft-repeated tale about struggling swimmers being forced to the surface by dolphins. One cannot go very far with such an interpretation because a human is involved instead of a fellow dolphin, but these instances should alert us to the possibility.

Mating activity.—During the spring of 1955, two male *Lagenorhynchus* were kept in the 80-foot circular display tank, with females of the same species, as well as with male and female *Tursiops truncatus*. On a few occasions the Pacific white-sided dolphins were observed to mate. More often, in fact nearly every day, interspecific matings between male *Tursiops* and female *Lagenorhynchus* were observed. Shortly after the arrival of the *Tursiops truncatus*, by air, from Florida, these animals began mating with female *Lagenorhynchus*. An example of unusually intense activity is recorded in the observations of October 20, 1954: "9:30–10 AM. The female *Lagenorhynchus* (considerably smaller than the two male *Tursiops*) was noted several times swimming up under one of the males (either one indiscriminately) rubbing her body against one of the male's front flippers. She swam along a little faster than the male, rubbing the dorsal surface of her body along his flipper until her tail flukes came in contact with it. At this point she usually slowed her swimming so that her flukes rubbed the flipper for several seconds. This action had the effect of exciting the male, and a number of times an immediate erection was the result. The male then swam after her, coming up from behind and usually from below to attempt intromission.

At times the males attempted to nip the little female after she rubbed against them. They attempted to take her tail stock in their mouths, and sometimes nipped at her flukes. Some nuzzling of the region around her vent was noted.

During an erection, the male *Tursiops* is able to swing the penis around in a half circle and thus can achieve intromission with an approach from either side. As the male came up from below, intromission was effected by the male sliding his tail and posterior abdomen under the female. At this time a strong vertical flexure of the male's body allowed him to "hook" the female. Usually this occurred only once but sometimes several attempts on a single pass were noted.

After intromission was completed, the female often flexed her body jerkily from side to side. She was heard to utter a series of squeaking noises at this time, and large amounts of air were ejected from her blowhole. Sometimes the female would swim down to the bottom of the tank (20 feet deep), after intromission, and rub her whole body jerkily against

the stipes of palm kelp (*Eisenia arborea*) which had been planted among the rocks. When she left the males, they rapidly lost interest until she sought them out and began caressing their flippers again. Fifty successful and attempted intromissions occurred in the space of one half hour.

These interspecific matings have been occurring nearly daily since the introduction of the Florida *Tursiops*. They were carried out as the males completely disregarded females of their own species. Sporadic matings have occurred between male and female *Tursiops* during the spring but none at all occurred during the winter. It may be that the spring mating period for *Tursiops*, observed by Essapian (1953), is the explanation, though such a mating season seems not to apply to *Lagenorhynchus*. The intensity of matings, interspecific and intraspecific, slackens during summer months.

The greatest mating activity is concentrated in the early morning hours, with some resurgence in the afternoon, McBride and Hebb (*loc. cit.*) report.

On March 31, 1955, a male *Tursiops* was noted pursuing a female *Lagenorhynchus*. At this time we had an adult male *Lagenorhynchus* in the tank (this practice is no longer followed, as male *Lagenorhynchus* are attacked and killed by the male *Tursiops*). This male *Lagenorhynchus* rushed up to the pursuing *Tursiops* and violently pushed him away from the female. The *Tursiops* swam off to another part of the tank.

Play.—*Lagenorhynchus* spontaneously invents games to play. It is seemingly not so inventive as *Tursiops*, but this may be due to the chunkier body, more rigid neck and smaller mouth of *Lagenorhynchus* which reduces its ability to move freely and to grasp large objects. The Pacific white-sided dolphin does not often nip or grasp objects with its mouth, as does *Tursiops*. It will play with a ball by pushing it with its snout or the top of its head, but it will seldom grasp it and has never been observed to throw, which is a common sport of *Tursiops*. A favorite game of captive *Lagenorhynchus* consists of balancing some floating object on the leading edge of a flipper and swimming along with it. Pieces of paper, or pelican feathers from the captive birds in the tank with the dolphins are standard playthings. Sometimes these graceful dolphins will balance a piece of paper on a front flipper and swim toward the bottom of the tank. When the paper slides off, it is delicately picked up by the leading edge of the tail flukes. These animals have also been seen balancing objects on their dorsal fins.

At one time we tried to keep a display of giant bladder kelp (*Macrocystis pyrifera*) in the tank with the dolphins. This alga consists of a large holdfast and a long twisted column of stipes that rise to the surface and end as a canopy of fronds. Our captive *Lagenorhynchus* swam constantly through this kelp and as they circled and approached the kelp, one or two animals would change their course, either swimming directly through the kelp or hooking stipes with their tail flukes. Once a loop of kelp became tightly cinched around the neck of one, just behind her blowhole where it stayed for two days. The kelp specimens in the tank were invariably reduced to a bundle of naked and broken stipes a few hours after their introduction.

COMMON DOLPHIN

Seasonal movements.—No seasonal migratory behavior for the species *Delphinus bairdi* Dall is evident from our data, although the common dolphin is more common in the Catalina Channel during the winter and spring months, when it is often seen with schools of the Pacific white-sided dolphin. However, some schools appear to stay in our inshore area throughout the year, unlike *Lagenorhynchus*, which goes offshore in summer and fall.

Our fishing is concentrated in the inshore waters, and thus the preponderance of records came from these areas. Nevertheless, our subjective impression is that *Delphinus* is even more common offshore, and that it is a somewhat more open-water species than is *Lagenorhynchus*. Many trips have been taken in nearshore areas without seeing dolphins of any sort. On the other hand, when we have ventured into offshore areas, beyond the innermost islands, *Delphinus* is often encountered.

Feeding.—We have recorded the common dolphin feeding both on anchovies and sauries.

TABLE 2.—*Locality records for Delphinus bairdi*

Locality	No. animals	Growth stage	Date
Midway between West End Santa Catalina Island and Osborn Bank	1	Adult	July 10, 1954
Between Osborn Bank and West End Santa Catalina Island	25 Approx.	Adults	July 17, 1954
4 mi. SW Catalina Harbor, Santa Catalina Island, Calif.	Small school		July 21, 1954
8 mi. off San Nicolas Island, Calif.	Small school		Sept. 4, 1954
2 mi. W. Dana Point, Orange County, Calif.	60 Approx.	Adults	Dec. 21, 1954
3–5 mi. S. Pt. Vicente, Palos Verdes Peninsula, Los Angeles Co., Calif.	Hundreds in 2 square mi.		Feb. 5, 1955
8–10 mi. S. San Pedro Lighthouse, Catalina Channel, Calif.	Large group	Adults	Feb. 11, 1955
9 mi. SW San Pedro Lighthouse, Catalina Channel, Calif.	Large group	Adults	Mar. 19, 1955
6 mi. NE White's Landing, Santa Catalina Island, Calif.	120	Adults	Apr. 13, 1955
7 mi. W West End Santa Catalina Island	20	Adults	Apr. 19, 1955
10 mi. S Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	30	Adults	July 24, 1955
8 mi. W. West End San Clemente Island	5	Half-grown	Aug. 6, 1955
3 mi. SW Catalina Harbor, Santa Catalina Island	20	Adults	Aug. 6, 1955
10 mi. SW Long Point, Palos Verdes Peninsula, Los Angeles Co., Calif.	30	Adults	Aug. 8, 1955
2½ mi. W. Pt. Vicente, Palos Verdes Peninsula, Los Angeles Co., Calif.	18	Adults	Aug. 12, 1955
11 mi. W. Pt. Vicente, Palos Verdes Peninsula, Los Angeles Co., Calif.	45	Adults	Aug. 30, 1955

In captivity it is notably less aggressive in its feeding than either *Lagenorhynchus* or *Tursiops*. Because of this it is extremely difficult to maintain this species in a community tank with the other two species. Captive *Lagenorhynchus* will race for any food thrown to *Delphinus*, sometimes forcing them out of the way with great violence. The *Lagenorhynchus* are impartial, meting out the same treatment to the larger *Tursiops*.

In nature, *Delphinus* has been seen feeding in company with *Lagenorhynchus* many times. Usually when they are found feeding together, small, separate groups of the two species occur in the same general area. On February 11, 1955, ten miles S. of San Pedro Lighthouse, a school of hundreds of *Lagenorhynchus* was located, feeding on anchovies. Around the periphery of this school were mixed groups of common dolphin and Pacific white-sided dolphin. When the two species travel together, they often move in completely mixed groups.

Schooling behavior.—In captivity *Delphinus* is the least adjusted of the three genera we have kept. It is timid and has little tendency toward play, whereas, in nature the opposite prevails. Schools of *Delphinus* can sometimes be identified at great distances because members leap high into the air as the school moves along (Pl. II). *Delphinus* will often cease feeding to play about the bow of a passing boat. *Lagenorhynchus* is much less inclined to do this and generally runs the bow well only when not feeding. The Common Dolphin

often criss-crosses in front of the bow of a vessel, slicing off with great speed away from the ship, only to return many times. *Lagenorhynchus* is more inclined to swim steadfastly at the bow for considerable lengths of time.

Young.—On April 13, 1955, two young *Delphinus bairdi* were seen travelling in a mixed school of approximately 200 adult common dolphins and Pacific white-sided dolphins. The smallest young was estimated at 2½ feet long and 50 lbs. in weight, and the larger one at three feet and 75 lbs. Neither animal seemed definitely to be swimming in company with a mother. No competitive behavior could be observed as these small animals ran the bow of the collecting boat *Geronimo*, which was in the midst of the school.

Observations of captives.—On July 17, 1954, the first common dolphin, a small adult female named Pauline, was caught in the Catalina Channel and placed into a concrete holding tank. On admission she was found to be in an advanced state of shock and could not

PLATE II

Delphinus bairdi, leaping alongside the Sefton Foundation research vessel *Orca*, two miles off Magdalena Bay, Baja California, Mexico. Photo by George Barlow.

remain at the surface without assistance. Adrenalin, administered intramuscularly, had no visible effect and so, after holding her at the surface by hand for some hours, we decided to devise "dolphin water wings" for her. Four gallon-sized glass jars were attached to her sides to serve as floats.

Little hope was entertained by those who watched her that evening, floating helplessly and breathing irregularly at the surface of the tank. It was with some surprise that, next morning, although her condition was not improved, we found her still alive. Pauline floated helplessly for the next two days, and probably would have succumbed if our collectors had not brought in a fine large male *Delphinus* on July 20. When this animal was placed into the tank, he immediately sought the company of the afflicted female, who in a matter of seconds, indicated by her movements her willingness to associate with her own kind, and made some effort to swim. We removed the bottles and Pauline began laboring slowly around the tank. The male sometimes swam under her and nudged her to the surface. Before long Pauline

was swimming fairly normally and the two animals became inseparable until the day of Pauline's death, two months later.

At the time of the male's capture, ointment containing 5 per cent sulfathiazole had been heavily applied around the wound site. This resulted in a toxic reaction, denuding an area of skin three inches square, exposing the blubber below. Shortly afterward, this fatty tissue commenced to degenerate and was removed, exposing healthy muscle tissue beneath. The area was smeared with penicillin ointment and the wound began slowly to heal. No further treatment was administered.

Pauline developed an abscess at the site of her hook wound and was treated, along with three *Lagenorhynchus*. Unlike these latter animals Pauline struggled continuously throughout her treatment, whistling her apprehension by forcing air through her blowhole.

The treatment given these animals as described for *Lagenorhynchus*, was generally effective but healing was very slow, principally because the blubber layer was excessively slow in regeneration and had very low resistance to additional abscessing. Our experience is that wounds inflicted on the head region heal much more quickly than those on the back and sides. Cursory examination indicates that this is associated with a higher degree of vascularity of the blubber in the head region.

Two weeks after introduction into the large display tank (Sept. 8) Pauline was found dead on the bottom of the tank. A necropsy disclosed the presence of a large abscess under the scar tissue of the original injury. The abscess had invaded the muscle tissue below and had entered the pleural cavity.

We were left with the single male *Delphinus* and four *Lagenorhynchus*. At the time of Pauline's death the male circled her body whistling constantly. The whistle of *Delphinus* is very high-pitched, so high as to be difficult for some people to hear it. Despite our constant efforts the male thereafter refused food and this fast continued until he died, three days later. During this time the animal ceaselessly circled the tank; whistling most of the time.

Examination revealed the presence of a perforated gastric ulcer. This ulcerous condition was probably aggravated by the animal's refusal to feed, resulting in a perforation, the ensuing peritonitis and death.

Healed gastric ulcer craters have since been found in two other specimens examined in our laboratory. The primary cause of these ulcers was not determined. The nematode parasites, *Anisakis* and *Contracaecum*, as shown by Schroeder and Wegeforth (1935), incite gastric ulcers in seals and sea lions. *Porrocaecum* does so in the sea otters (Rausch, 1953). These have not been found in dolphins examined at Marineland of the Pacific. It is possible that ulcers may be initiated by some item of diet, such as the spines and bones of fishes.

ATLANTIC BOTTLENOSE DOLPHIN

This remarkable species, *Tursiops truncatus* (Montague), is the world's best known dolphin primarily because of the observations recorded at Marine Studios in Florida (McBride and Hebb, 1948; Essapian, 1953). We have found it an intelligent animal with a degree of inventiveness that is matched by few other mammals. We use the term *intelligence* here in a rather vague sense in referring to *Tursiops*. A comparison of the intelligence of this wholly aquatic mammal with terrestrial species as a standard, is difficult. Still we say *Tursiops* is *intelligent* because its behavioral range seems to far exceed that necessary for survival, learning is rapid and requires relatively little repetition, a degree of reasoning ability seems present, and the species indulges in pure play, not for the sake of reward. A few of our observations follow: (Our *Tursiops* are named Frankie, Floyd, Mabel and Myrtle.) October 1, 1954: Frankie was seen playing with a pelican primary feather. Repeatedly he released this feather near the bottom of the tank, below the incoming water jet. The feather drifted up, was caught in the current and swept up into the tank. Frankie retrieved the feather and repeated this over and over. This behavior still continues with all *Tursiops* participating. Some of the feathers have been obtained by the porpoises pulling them directly from the pelicans. Often the big animals will come to the surface and throw

the feather into the air and catch it. They often try to throw the feathers out of the tank to spectators standing around the railing. Sometimes they succeed.

The fishing activities of these animals are interesting. The four Atlantic bottlenosed dolphins were introduced into a tank where a sizeable fish display had been unmolested by the *Lagenorhynchus* and *Delphinus*. This did not last long. A typical case was observed on October 6. The four *Tursiops* were found harrying a single three-pound kelp bass (*Paralabrax clathratus*). When this bass swam into a crevice, 2, 3 or 4 of the *Tursiops* would harry it, one or two on each end of its hiding place. When one porpoise snapped, the bass moved and was snapped at by the others. Finally the bass fled its retreat and raced across the tank, pursued by all four dolphins. In their efforts to catch the bass these dolphins turned in all sorts of body contortions in the water, upside down, craning their flexible necks and pushing their snouts far into crevices. Although there were many fish in the tank only one bass was pursued, except for one instance when they chased a bass of similar size but quickly left it and returned to their original prey. Finally the first bass was caught. Several times it was grasped by the dolphins without being bitten severely. Bottlenosed dolphins definitely harry their prey. Finally the bass was carried off by Mabel, she tossing and catching it in the open water and finally swallowing the fish, head first.

October 5, 1954: Frankie invented a new game for himself today. He swam to the bottom, picked up a pebble about 1½" in diameter, and threw it at one of the customers standing at the edge of the tank. The man threw the pebble back in the pool. Frankie retrieved the pebble and, even though many people were leaning on the railing, he threw it back to the same man. The two went through this routine eight times.

The captive *Tursiops* have thrown fish back to the feeder when they became full. When small fish are introduced into the tank most of them are captured, some are eaten and others are thrown out of the tank alive, and generally unharmed. *Tursiops* is very adept at throwing things. They love to play with rubber balls, the size of a volley ball or smaller. They take these balls in their mouths, poke their heads above surface, and throw them with a quick lateral flick of their heads. They are able to throw 20 feet or so with considerable accuracy. They even throw under water. One favorite trick is to toss a ball downward as they swim along under water. The ball descends a foot or two and then pops back toward the surface, but before it can reach the top it is taken again and the process repeated. This behavior looks strikingly like a basketball player "dribbling," only of course, it is under water and the ball never touches the floor. Many times, when the dolphin becomes tired of playing, the ball is taken down to the rock reefs on the bottom and "stored" in a crevice or under an overhanging rock.

The *Tursiops* have been observed playing with the moray eels (*Gymnothorax mordax*) several times. These eels are mostly adults about 4 feet long, quite aggressive, and can inflict a vicious bite. They live in the holes and crevices of the rock decorations. The dolphins learned to pull them from their hiding places and into the open water in the middle of the tank. There they let the eels slither through their jaws. Once one of the eels turned around and bit the dolphin, who immediately released it, but was back in a few moments playing with the eel again. The same sort of treatment is given most other fish in the tank, so our display has been reduced to a few hardy species such as bat rays (*Myliobatis californicus*), swell sharks (*Cephaloscyllium uter*), and leopard sharks (*Triakis semifasciata*). *Tursiops* kills pelagic sharks in a short time, usually by ramming the shark's sides or gills with its rostrum (Essapian, *loc. cit.*). Such treatment is occasionally given to the leopard sharks, which are bottom dwellers. One leopard shark, about five feet long, was seen swimming along the tank bottom. One of the male *Tursiops* swam up with considerable speed, hitting the shark at midbody with his rostrum. The shark was bent nearly double by the force of the impact and much bottom gravel was forced along the opposite side of the shark's body. A second pass was made but the dolphin missed. Apparently the shark was not harmed.

One observation, which is tempting but difficult to interpret, occurred on October 25, 1954. Frankie and Floyd were trying to haul a moray out of its crevice. One dolphin was on

each side of the crevice working the moray back and forth. They could not dislodge the eel. One dolphin left the scene, killed a newly introduced scorpion fish (*Scorpaena guttata*) and returned to the crevice with the fish in his mouth. The scorpion fish is a species with sharp and painfully poisonous dorsal spines. The *Tursiops* poked at the eel with this fish, apparently prodding it with the spines. The eel abandoned its crevice, was caught and taken to the middle of the tank and released.

On February 23, 1955, we placed four adult electric rays (*Torpedo californica*) into the circular tank. The *Tursiops* were, as usual, curious about the new arrivals. They began nipping at the tails of the rays. Every time a ray was nipped, it immediately spun around in the water like a saucer and faced the antagonist, which would not attack the ray from this angle. Four times the rays shocked the *Tursiops*. Each time the ray was more or less facing the dolphin and was either above or below it. When the ray discharged, its whole saucer-shaped body could be seen to contract. The shock was effective at least a foot from the ray as the dolphins recoiled from a shock at this distance, but suffered no injury. The rays weighed between 40 and 50 pounds.

Sexual play of one sort or another occurs nearly every day. The interspecific matings are perhaps to be classed in this category. Homosexual matings have occurred many times between the two male *Tursiops*. These two males mate with virtually anything and everything that is animate. They have attempted mating with skates, bat rays, leopard sharks, green turtles, and even moray eels. It has proved embarrasing to the public to have the big males come to the surface during feeding shows, ignore the routine, and attempt mating with a struggling eel. When a diver descends into the tank he sometimes pets the big dolphins as they cluster curiously about him. Many times this seems to excite the males and erections result. One diver was pushed against the tank wall by a big male, after he had petted the animal. The dolphin "clasped" the diver with his front flippers and shook him for a moment.

DALL'S PORPOISE

Published records for Dall's porpoise, *Phocoenoides dalli* (True), in California waters are relatively few (Benson & Groody, 1942; Schaeffer, 1942; Benson, 1946; Yocom, 1946). However, the animal is of common occurrence in the southern California area.

Lustig (1948) reports three sightings in the Channel Islands area: (1) July 6, 1936 a school of 20, 2 miles off Pyramid Head, San Clemente Island; (2) June 27, 1939, school of

TABLE 3.—*Locality records for Phocoenoides dalli*

Locality	No. animals	Growth stage	Date
2 mi. S. Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	7	Adults	March, 1954
3 mi. SW Pt. Vicente, Palos Verdes Peninsula, Los Angeles County, Calif.	2	Adults	Nov. 4, 1954
¾ mi. S. Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	4	Adults	Nov. 10, 1954
11 mi. W. West End Santa Catalina Island, Calif.	12	Adults	Dec. 9, 1954
2 mi. W. Dana Point, Orange County, Calif.	12	Adults	Dec. 21, 1954
LeSuen Sea Mount (14 Mile Bank) between Newport and East End Santa Catalina Island	16	Adults	Jan. 12, 1955
Catalina Channel, 9 mi. offshore, between Pt. Firmen and the Isthmus of Santa Catalina Island.			May 4, 1955

Note: Reports of fishermen and others indicate that it may be common in the vicinity of Anacapa and Santa Cruz Islands.

30 East Point of Santa Rosa Island; (3) July 13, 1939, 10–12 animals, Anacapa passage, between Santa Cruz Island and Anacapa Island.

When all records are considered it becomes apparent that *Phocoenoides* may undergo a seasonal migration like that postulated for *Lagenorhynchus*. All winter records are for the inshore areas and all summer records are for the northern and outer island areas.

Yocom (1946) reports the Dall's Porpoise to be common in the offshore areas near the Farallone Islands.

Feeding.—We have seen this porpoise feeding only among schools of anchovies (*Engraulis mordax*), sometimes among the same school as groups of common dolphins and Pacific white-sided dolphins. On one occasion (Nov. 4, 1954) two adult Dall's porpoise were seen working anchovies in close proximity to two killer whales (*Grampus rectipinna*), which were apparently adult females. Lustig (*loc. cit.*) reports *Phocoenoides* feeding on anchovies and sauries in the Anacapa Passage.

Schooling behavior.—No large schools of this species have been noted. It is among the easiest of small cetaceans to identify from a distance by the habit of literally throwing itself along through the water, making a considerable splash each time its head reenters the water. Its tail stock is so deep that it creates a very peculiar impression as it arches up out of the water when the animal dives. It looks something like a large black and white square rolling over. Seldom does it run the bow of a boat but when it does it rockets in under the bow, veers off and usually disappears in a great burst of speed. We have seldom had the animal stay close to the ship for more than a few seconds. This is contrary to the behavior of *Phocoenoides* reported by Yocom (*loc. cit.*).

Body coloration.—One of the distinguishing characteristics of this species is a white patch along the trailing edge of the dorsal fin, once thought to be characteristic of P. *truei*. Two individuals have been sighted by our collectors, Frank Brocato and Frank Calandrino, which had solid black dorsal fins.

PACIFIC PILOT WHALE

Seasonal occurrence.—The pilot whale or blackfish (*Globicephala scammoni* Cope) is quite common in southern California waters. It seems to enter the Catalina Channel sporadically throughout the year, though our records are most numerous during the winter months. From December 1, 1954 to February 13, 1955, a whale watch was kept from the top deck of the Oceanarium building to obtain a count of migrating California gray whales (*Rhachianectes glaucus*). During the course of these observations we sighted a number of schools of pilot whales.

Schooling behavior.—Like their smaller relatives, *Delphinus* and *Lagenorhynchus*, the Pilot Whale travels in tight schools when it is not feeding, but disperses into scattered groups on the feeding grounds. From the Oceanarium roof, during the course of our whale watch, several times we saw tight schools of *Globicephala* swimming up the channel from the southeast. As they reached Pt. Vicente, just to the west of us, the schools often dispersed and circled about in widely scattered groups during most of the day, apparently feeding. As dusk began to fall the school came together, turned, and swam back down the channel to the southeast.

There is little uniformity as regards the behavior of these animals to a passing boat. Many times they will flee when the boat is a considerable distance away, usually sounding. On the other hand we have had a 14–16 foot individual allow us to approach until the bow was nearly over its back, so close that the animal had to move out of the way in order to avoid being hit. On another instance two of our men were trying to photograph these animals under water when one animal came up under the skiff and nearly upset it. Big adults seem to shun waters very close to shore.

Young.—On January 25, 1955, our Chief Collector and his assistant noted a school of 20 small *Globicephala* ten miles SE of San Pedro Lighthouse. These animals were estimated at 7–10 feet in length. On the same day a large adult was seen in close company with a young animal estimated at 90–100 lbs. in weight.

TABLE 4.—*Locality records for Globicephala scammoni*

Locality	No. animals	Growth stage	Date
Clemente Channel, between San Clemente Island and Santa Catalina Island, Calif. (during this month similar schools were noted on seaward side of Santa Catalina Island and in Catalina Channel, though no data were taken)	40–50	Adults	July 12, 1954
2½ mi. NE of Avalon, Santa Catalina Island, Calif.	15	Small adults	Dec. 8, 1954
12 mi. NW of West End Santa Catalina Island, Calif.	5	Adults	Dec. 9, 1954
12 mi. SW Santa Catalina Island, Calif.	7	Adults	Dec. 9, 1954
2 mi. off Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	20	Small animals	Dec. 12, 1954
2 mi. off Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	50	Small animals	Dec. 18, 1954
1–5 mi. off Long Point, Palos Verdes Peninsula, Los Angeles County, Calif. (seen all day)	20	Small animals	Dec. 19, 1954
Off Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	20	Small animals	Dec. 27, 1954
Off Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	30	Small animals	Dec. 28, 1954
5–8 mi. off Long Point, Palos Verdes Peninsula, Los Angeles Co., Calif.	30	Small animls	Dec. 29, 1954
1½ to 2 mi. off Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	60	Small animals	Jan. 14, 1955
½ mi. S. Pt. Vicente, Palos Verdes Peninsula, Los Angeles County, Calif.	Small school	Small animals	Jan. 15, 1955
½ mi. off Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	Small school		Jan. 20, 1955
Off Pt. Vicente, Palos Verdes Peninsula, Los Angeles County, Calif.	Small school		Jan. 21, 1955
Off Pt. Vicente, Los Angeles County, Calif.	20 Small school	Large adults. Small animals	Jan. 22, 1955
10 mi. E. San Pedro Lighthouse, Los Angeles County, Calif.	20	Small animals	Jan. 25, 1955
¾ mi. off Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	8		Feb. 5, 1955
8 mi. S. Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	20	Adults	Apr. 13, 1955
10 mi. off Long Point, Palos Verdes Peninsula, Los Angeles County, Calif, spreading out as far as could be seen.	Very large school. Perhaps a hundred animals could be seen at one time		July 24, 1955
13 mi. SW Catalina Harbor, Santa Catalina Island, Calif.	12	Adults	Aug. 6, 1955

PACIFIC KILLER WHALE

Seasonal occurrence.—The killer whale, *Grampus rectipinna* (Cope), occurs sporadically in southern California waters. Our records are all from fall and winter but are too few to support a conclusion about a possible seasonal migration.

On November 2, 1954, the trawler, *Cecelia*, of Santa Barbara, California, skippered by Victor Castagnola, brought up two adult basking sharks (*Cetorhinus maximus*) in her net. To prevent the net from being ripped to pieces by these huge fish the skipper killed them with a shot gun. They were rolled out of the net into about 60 feet of water. We cruised by the next day on board the *Geronimo* and found seven *Grampus* circling and feeding on these sharks. In the group were two adult males which we estimated to weigh 6,000 lbs. each, one somewhat smaller male, two females weighing about a ton, and two young animals estimated at 600 lbs. each. The two adult females swam up to the *Geronimo* as we cruised along at three knots, going directly under the skiff that we were towing eight feet behind our stern. These females turned on their sides, as if inspecting the skiff. One rolled completely over and both rose to the surface and blew within three feet of the skiff. One was seen swimming under the stern with a large piece of basking shark flesh protruding from both sides of her jaws. We could not approach the males so closely, getting within 75 feet or so. Pieces of shark liver were floating over the sea and the air was filled with gulls. Several times the killer whales threw their flukes and we could see the white ventral surface edged with black. The exhalation of these animals is very noisy and powerful and it would appear as if considerable pressure is built up before the air is expelled.

On December 28, 1954, ten killer whales were sighted off Portuguese Bend, just east of the Oceanarium, swimming very close inshore (as close as 150 feet off the rocks). They passed the Oceanarium very close inshore. Two of the animals leaped clear of the water directly in front of the Oceanarium. One old male and one female made the leaps. These leaps gave us a fine view of the enormous rounded pectoral flippers, which are white ventrally. The five adult males usually surfaced in a tight group and were always separate from the four females and single young animal. These two groups were within a few feet of each other as the animals traveled along.

TABLE 5.—*Locality records for Grampus rectipinna*

Locality	No. animals	Growth stage	Date
North side of Anacapa	2	Large adult males	Oct. 29, 1954
	2	Large adult females	
	1	Young	
1 mi. S of Montecito, Santa Barbara County, Calif.	2	Adult males	Nov. 3, 1954
	1	Subadult male	
	2	Adult females	
	2	Young	
3 mi. SW of Pt. Vicente, Los Angeles County, Calif.	2	Adult females	Nov. 4, 1954
1 mi. S. of Long Point, Los Angeles County, Calif.	8	Adult males	Dec. 18, 1954
	2	Adult females	
	1	Half grown	
150 feet offshore from Long Point, Los Angeles County, Calif.	5	Adult males	Dec. 28, 1954
	4	Adult females	
	1	Young	
¼ mi. off Long Point, Palos Verdes Peninsula, Los Angeles County, Calif.	1	Adult male	Sept. 14, 1955

Marineland's head diver, Ted Davis, while working aboard a tuna clipper, watched a group of 15 to 20 *Grampus* attacking a school of about 100 dolphins in the vicinity of Alijos Rocks, off Baja California, Mexico. This occurred during the fall of 1947. He reports that the killers swam in circles around the dolphin school, gradually crowding them tighter and tighter. Finally one of the killers veered off, rushing at the shool, while the others continued circling. In this fashion, the killers ripped at the school one at a time, killing many of the dolphins. The water was red with blood. The dolphins were of a type called "white belly porpoises," by the tuna fishermen, presumably *Delphinus bairdi*.

LITERATURE CITED

BENSON, S. B., AND T. C. GROODY. 1941. Notes on the Dall porpoise (*Phocoenoides dalli*). Jour. Mamm., 23: 41–51.

BENSON, S. B. 1946. Further notes on the Dall porpoise. Jour. Mamm., 27: 368–374.

COWAN, I. M. 1944. The Dall porpoise, *Phocoenoides dalli* (True), of the northern Pacific Ocean. Jour. Mamm., 25: 295–306.

ESSAPIAN, F. S. 1953. The birth and growth of a porpoise. Natural History, 62: 392–399.

HUBBS, C. L. 1953. Dolphin protecting dead young. Jour. Mamm., 34: 498.

LUSTIG, B. L. 1948. Sight records of Dall porpoises off the Channel Islands, California. Jour. Mamm., 29: 183.

MCBRIDE, A. F., AND D. O. HEBB. 1948. Behavior of the captive bottle-nosed dolphin, *Tursiops truncatus*. Jour. Comp. and Physiol. Psych., 41: 111–123.

MOORE, J. C. 1953. Distribution of marine mammals to Florida waters. Amer. Mid. Nat., 49: 117–158.

NORMAN, J. R., AND F. C. FRASER. 1949. Field book of giant fishes. G. P. Putnam's Sons, New York. 376 p.

RAUSCH, R. 1953. Studies on the helminth fauna of Alaska. XIII. Disease in the sea otter, with special reference to helminth parasites. Ecology, 34: 584–604.

SCHEFFER, V. B. 1942. Further records of the Dall porpoise in California. Jour. Mamm., 23: 221.

———. 1950. The striped dolphin *Lagenorhynchus obliquidens*, on the coast of North America. Amer. Midl. Nat., 44: 750–758.

SCHROEDER, C. R., AND H. W. WEGEFORTH. 1935. The occurrence of gastric ulcers in sea mammals of the California coast, their etiology and pathology. Jour. Amer. Vet. Med. Assoc., 87, N. S. 40: 333–342.

YOCOM, C. F. 1946. Notes on the Dall porpoise off California. Jour. Mamm., 27: 364–368.

Marineland of the Pacific, Marineland, California. Received October 31, 1955.
[Contribution of Marineland of the Pacific Biological Laboratory, No. 1]

BODY TEMPERATURE IN THE NORTHERN FUR SEAL, *CALLORHINUS URSINUS*

By George A. Bartholomew and Ford Wilke

Statistically significant samples of the body temperature of large wild mammals are ordinarily almost impossible to obtain. In the case of the northern (Alaska) fur seal, however, a sample of almost any desired size can be secured if one uses the animals involved in the annual commercial kill.

Body temperatures of fur seals are of interest not only because of the large samples available but because of the species' size (up to 600 pounds), its high degree of specialization for an aquatic mode of life, and the fact that it lives in an environment where heat stress, in the usually accepted sense, is nonexistent.

For any marine mammal the problem of heat loss to the water is always acute. Even at the extreme southern limit of the northern fur seal's winter range the difference between body temperature and environmental temperature is 20°C. or more. During much of their aquatic existence many of the adults operate in waters averaging only a few degrees above zero C. The insulation of hair and blubber necessary for the maintenance of body temperature while in the water presents a considerable physiological problem when the animals participate in violent and prolonged activities on shore during the breeding season, even though their rookeries in the Pribilof Islands are characterized by almost continuous summer overcast and air temperatures rarely rising above 12°C.

Acknowledgments.—This work was carried out in the Pribilof Islands during the summer of 1951 in collaboration with the United States Fish and Wildlife Service under the general sponsorship of Dr. Victor B. Scheffer. Mr. Clarence Olson and Mr. Charles H. Anderson made available the facilities of St. Paul Island and gave every possible cooperation. Mr. Karl Kenyon assisted in obtaining the temperatures from the pups and from some of the adult bulls and cows.

Methods.—All temperatures were measured with a quick-acting mercury thermometer. The temperatures taken during the commercial kill were obtained within a few seconds of the time the animals were stunned by clubbing. The unconscious animals, hauled into line preparatory to skinning, are routinely killed by making a longitudinal midventral incision into the thoracic cavity (frequently into the heart itself). The thermometer was thrust through this incision into the still-beating heart, or immersed in the pool of blood being pumped into the thoracic cavity from the punctured heart or severed aorta. Thoracic temperatures were also obtained from animals killed for other purposes—parasitological examination, reproductive histology, or age determination. These seals were shot from close range. Temperatures were obtained from the still living but unconscious animals within 10 or 15 seconds of the impact of the bullet. A small puncture was made in the wall of the chest and the thermometer was inserted through it to a depth of 3 or 4 inches. Rectal temperatures were obtained from a thermometer inserted 3½ to 4 inches, and scrotal temperatures were obtained through a small slit in the scrotum. All the temperatures of the pups were obtained from unharmed individuals captured on the inland edge of the rookery.

RESTING TEMPERATURES

The results of measurements on 323 animals are summarized in Figure 1.

Adults.—The mean temperature of 13 adults (8 males, 5 females) killed while they were at rest and under no apparent temperature stress (air temperature, 8 to 9°C.) was 37.7°C. There was no difference between the body temperature of the bulls and the cows.

Pups.—The mean rectal temperature of 30 pups varying in age from 2 to 6 weeks was 38.2°C. It is possible that the true resting temperature is somewhat

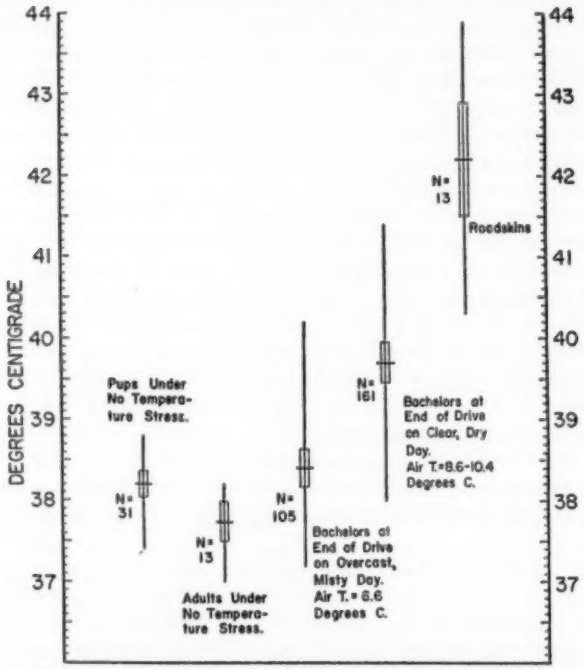


FIG. 1.—Body temperature in the northern fur seal. The vertical lines indicate the range for each sample; the horizontal lines show the mean (M); the rectangles indicate the interval $M + 2\sigma_M$ to $M - 2\sigma_M$; and N indicates the number of animals measured.

lower, because most of the temperatures were taken on what by local standards was a warm day (12.4°C.) and the pups became excited by the handling involved in the determination of their temperature. However, the temperatures of two captive pups held for parasitological studies were 38.0 and 38.1°C. respectively.

EFFECTS OF SUSTAINED TERRESTRIAL ACTIVITY

Under ordinary circumstances seals only occasionally experience a situation where their limited capacity for heat dissipation presents a serious problem. During the commercial kill, however, animals sometimes become overheated

and occasionally die from heat exhaustion even though the air temperature may be less than 10°C.

The animals taken in the commercial kill are the bachelors that aggregate on the inland edge of the harems. For convenience of handling and to avoid disturbing the organization of the harems the bachelors are driven inland and then herded slowly overland to some level, grassy area where the killing and skinning takes place. The drive may be as short as a quarter of a mile or as long as three-quarters of a mile. Even on cold damp mornings the bachelors may be panting before they have traveled 50 yards, and by the end of the drive they often show signs of severe heat distress although heat prostration is rare. The sealers make every effort to herd the animals at a leisurely pace but it is impossible to prevent them from moving about excitedly.

The drives to the killing grounds provide an excellent opportunity to measure the effects of exertion on the body temperature and to determine to some extent the degree to which the capacity for heat dissipation is affected by weather conditions. The lability of the body temperature of fur seals is conspicuous. It will be noted (Fig. 1) that both the samples taken at the end of the drives to the killing grounds are significantly higher than the sample from resting adults; the means of the two former samples are approximately 1 and 3° respectively higher than the latter. Moreover, the sample taken on a relatively warm day on the killing ground was significantly higher than that taken on the cool day. In addition on the warm day a number of animals died of heat prostration during the drive to the killing grounds, while none died or even appeared seriously stressed on the cool day.

Heat prostration.—We were fortunate in participating in the drive on the one morning during the season of 1951 in which more than a few fur seals suffered heat prostration. The drive began at 4:15 AM on June 25, and the kill was ended at 7:40 AM. Weather conditions were unusually pleasant for summer in the Bering Sea. The only overcast was a cover of cirrus; the air was quite dry—the night had been dewless—and a 4 to 8 mile per hour north northwest wind was blowing. From Reef Rookery to the killing ground is approximately 0.7 miles. The drive took about 90 minutes and the seals were frequently allowed to rest along the way. The air temperature was 8.6°C. at the beginning of the drive and had risen to 10.4°C. by the end of the kill. The seals were panting heavily and frequently paused to wave their hind flippers in the air before they had been driven 150 yards from the rookery. By the time the drive was half finished most of the seals appeared badly tired and occasional individuals were dropping out of the pods. In the last 200 yards of the drive and on the killing grounds there were found 16 "roadskins" (animals that had died of heat prostration) and in addition a number of others prostrated by overheating and so incapacitated that we were able to take their rectal temperatures without much trouble. Some in this latter group recovered.

To obtain a quantitative measure of the overheating experienced by the animals as a group, we measured the deep body temperature of 161 of the bachelors immediately after they were stunned (Fig. 1). The elevation of body tempera-

TABLE 1.—*Body temperature and heart rate in fur seals during heat prostration*

Age in years	Rectal temp. in °C.	Heart beats per minute	Remarks
6	40.3	—	Recovering, too active to take pulse
4	41.4	186	Completely helpless, dying, probably cooling off
4	42.1	—	Convulsive panting, too active to take pulse
5	42.4	224	Gasping, vomiting, completely helpless
3	42.7	—	In convulsions (data from Hanna, 1924)

ture above the resting level was conspicuous. Only 2 of the 151 animals had temperatures that fell within the range of the resting sample; all the rest were elevated, some almost 4°C., above the mean of the resting sample.

The roadskin sample is less reliable than the others shown because it includes animals recently dead as well as those in the process of dying from heat prostration. Under field conditions there was no way of determining whether or not the temperature we took represented the maximum attained by that individual or some level in its cooling off. The lower part of the roadskin distribution probably represents animals that had cooled from some higher temperature. The sample is nevertheless instructive. That part of the sample lying above 41.5°C. includes 10 of the 13 animals in the group and demonstrates clearly the lability of their temperatures and the rather startling tendency to die from overheating even at low environmental temperatures. The three highest temperatures that we recorded, 43.9, 43.7, and 43.6, were obtained from dead animals. The condition of the live animals in the roadskin group from which we could get data is summarized in Table 1. From the data presented in Figure 1 and Table 1 several conclusions can be made: (1) the ability of the northern fur seal to dissipate heat is so limited that, even when air temperatures are as low as 10°C., severe exertion on land will lead to heat exhaustion and death; (2) the lability of fur seal body temperatures is pronounced, and intense activity on land may cause the body temperature to rise to as much as 44.0°C.; (3) body temperatures higher than 41.5 are found only in animals incapacitated by heat exhaustion; (4) animals prostrated by heat exhaustion may recover, at least temporarily, after a period of rest.

Death from heat exhaustion has been familiar for many years to persons working with the northern fur seal. Every season scores of seals become roadskins. Table 2 summarizes the data on roadskins available in the records of the Fish and Wildlife Service for a typical five-year period. During this five-year period 413 animals died of heat exhaustion. During the same period the commercial kill was 323,000 and the number of animals driven to the killing grounds was at least one-third again as high. Thus it is reasonable to suggest that during a typical season between 1 in 800 and 1 in 1000 of the animals driven to the killing grounds dies of heat prostration. Although, except for the material presented in the present paper, no measurements of air temperature taken during the drives is available, it has been a matter of common observation for many years that the number of roadskins is greatest on warm clear days and smallest on cool

TABLE 2.—*Deaths from heat prostration during drives to killing grounds*

Year	Total deaths	Max. deaths on any one drive	Max. per cent on any one drive
1947	142	46	9.8
1948	174	112	4.7
1949	24	5	0.4
1950	48	34	3.4
1951	25	16	5.0

rainy days. As shown in Table 2, on exceptional days roadskins may represent 5 or even 10 per cent of the kill. This underscores the fact that the islands of the Bering Sea, even with their cold wet summers, furnish a habitat that is barely adequate as far as the thermoregulatory ability of fur seals is concerned.

TEMPERATURE REGULATION

Role of pelage.—From the discussion above, it is obvious that while on land the bulls, bachelors, and cows are never faced with a serious problem of heat conservation. The pelage of adult fur seals is so dense that the skin of the furred parts of the body is probably never wetted. The pups, however, have a short, sparse, coarse pelage that is easily wetted and appears to be a relatively inadequate insulator. As far as we can judge from field observations, neither pups nor adults utilize pilomotor activities to vary the insulating capacity of their pelage while on shore.

Role of flippers.—The density of the adult pelage, together with the thickness and general distribution of the blubber, allows only the naked parts of the body (the inguinal area and the flippers) to serve as effective avenues for heat dissipation. The importance of the appendages, particularly the hind flippers, in the facilitation of heat loss needs no laboratory demonstration; it is clearly demonstrated by the behavior of the fur seals while on shore and strongly suggested by some of their activities while in the water.

In all members of the family Otariidae the front flippers are very large. In *Callorhinus* the hind flippers also are large, being extremely long, and gracefully tapered dorsoventrally, and each digit terminates in a slim flap. These elongate hind flippers may well be of major assistance in aquatic locomotion although no study of this has yet been made. The importance of the long hind flippers in thermoregulation during terrestrial activities, however, is obvious after even the most cursory observations of fur seal behavior on the breeding grounds. Microscopic examination of samples of integument showed that both front and hind flippers are abundantly supplied with large, well developed sweat glands. The flippers are further adapted to function in heat transfer by their vascularity and black color. Even on the coolest of summer days in the rookery, whenever the bulls engage in strenuous activity incidental to territory maintenance or copulation, there usually follows a period of vigorous fan-like waving of the hind flippers. The postures assumed during flipper-waving are various. Those shown in Plate I are typical. The animal may lie prone and wave its flippers synchro-

nously, or it may hold its forequarters erect and rotate its pelvis so the flippers are free to wave laterally. Presumably the waving of the flippers facilitates heat loss both by radiation and by evaporation of sweat from the abundant sweat glands on the flippers. During the waving the digits are spread widely, exposing a maximum of surface area.

Flipper waving is most conspicuous in the males, presumably because they are the most active animals in the rookery and hence the ones most often overheated. Pups almost never show this behavioral response, probably because their

PLATE I

Temperature regulation by panting and flipper-waving in the northern fur seal, Kitovi Rookery, St. Paul Island, Alaska. The heat stress of these animals was produced by sunlight filtered through a high thin overcast and an air temperature of 13°C.

pelage is too thin and their insulation too poor to require them to accelerate heat loss. During approximately two months of daily observations in the summer of 1951, waving of flippers by pups was seen on only one day, July 22, when the air temperature reached 13.0°C. In this instance a dozen or more pups, out of the hundreds within view, waved their flippers jerkily and erratically from time to time. At the same time over 95 per cent of the cows and bulls were waving their flippers energetically (Pl. I).

Panting.—Despite the coolness of the climate in the Pribilofs, fur seals pant frequently. Almost any activity while on land causes them to resort to this mechanism of heat loss. While panting they open the mouth wide but do not extrude the tongue conspicuously. The bulls pant with great vigor and produce

a distinctive harsh rasping sound that is used incidental to aggressive activities. Its precise utility in this respect has not been determined. When overheating is due to activity, the animals pant while in any one of their many usual resting postures, but when it is due to unusually warm weather or to unusually intense solar radiation, they frequently elevate the forequarters and throw the head back so that their open mouths point almost vertically (Pl. I). Both the cows and the bulls pant heavily and frequently, but pups almost never do so.

Shivering.—The newborn pups have a sparse pelage and are relatively susceptible to chilling. The adults with their beautifully dense pelage are relatively impervious to low environmental temperatures. The pups, even when only an hour or so old, often shiver vigorously while moving about, while asleep, and whenever rain falls. Shivering was never observed in the bulls and observed only once in the cows. In this instance the animals were lying exposed to a 20 mile per hour wind, a driving rain, and an air temperature of 6°C. Even so, only a few cows out of the hundreds in view were shivering.

Posture.—While floating in the water, resting, or sleeping, fur seals assume a posture that should afford a measure of heat conservation. Since heat loss through conduction is more rapid in the water than in the air, it would be advantageous for a seal sleeping or resting in the water (and having therefore a low rate heat of heat production) to minimize heat loss through its appendages, because they are the primary site of heat loss. It is possible that vasoconstriction is important in this respect, but the characteristic postural response also appears to be significant. While floating quietly in the water they lie on back or side with the hind flippers in the air, pressed together and directed cephalad, and with one of the front flippers (occasionally both) pressed against the hind flippers so that at least three flippers are held clear of the water. They often use the front flipper that is under water to balance themselves and sometimes scull along briskly with it.

On cool or rainy days the seals on shore ordinarily lie on their bellies with both front and hind flippers tucked in underneath their bellies, which probably minimizes heat loss.

Scrotal temperatures.—Like other otariids, male northern fur seals have descended testes. During terrestrial locomotion the scrotum is inconspicuous but during the flipper waving described above it becomes pendulous. The scrotum of fur seals has the same thermoregulatory role as in other mammals. Scrotal temperatures were measured in four adult bulls which were killed for histological purposes (Table 3). The mean thoracic temperature was 37.7°C.; the mean scrotal temperature, 29.8°C. The minimum difference between deep body and scrotal temperatures in any of the four bulls was 6.2°C.

Effects of environmental temperature.—Whenever the sun breaks through the heavy overcast that is almost continuously present in the Bering Sea during the summer, the change in behavior of the seals is conspicuous. The level of general activity decreases sharply; the frequency of harem maintenance and copulatory activity diminishes; and flipper waving and panting become almost universal among the adults. If the air temperature rises to as much as 12°C., small groups

TABLE 3.—*Thoracic and scrotal temperatures in adult bull fur seals*

Age in years	Temperature in °C.		
	Thoracic	Scrotal	Air
10	37.8	28.6	8.0
10	38.2	29.2	8.0
—	37.0	30.8	8.2
10	37.6	30.8	8.3

of females begin to leave the rookery. Apparently even this moderate temperature is uncomfortable enough to cause them to return to the water. The cows also return to the water when unusually hard rains develop. In the case of the rain, the exodus to the sea is more general and conspicuous than in warm weather. It is probably related to the discomfort of the pelting rain itself rather than to heat loss.

DISCUSSION

Instances in which temperature tolerance *per se* directly limits the distribution of adult birds and mammals are not common. However, the failure of the northern fur seal to regulate its body temperature during sustained activity on land and its obvious sensitivity both to moderate air temperatures and to low levels of solar radiation probably restricts the location of its breeding grounds and perhaps the extent of its movements during the pelagic phase of its activities.

It is hardly an exaggeration to say that summers in the Pribilofs are barely cool enough to allow the fur seals to breed there. It is reasonable to assume that no islands in the North Pacific south of the Aleutians afford summers cool enough and with a sufficient amount of overcast weather to induce *Callorhinus* to establish breeding colonies.

The fur seal, during its pelagic life, is an animal of cold water seas. The bulls are believed to remain in the extreme north Pacific, rarely venturing much south of the Aleutians, but the females and young males migrate south across the whole breadth of the North Pacific, from Japan to the United States. During pelagic seal hunting off the coast of Japan, no fur seals were found in waters warmer than 14.0°C. and occurrence was most frequent in waters with a temperature of approximately 11°C. (Wilke, 1951). In the eastern Pacific also, northern fur seals confine themselves to relatively cool waters. They occur with some regularity in the offshore waters of southern California and occasionally off the coast of northern Baja California. Dr. Carl L. Hubbs (personal communication) states that, at the southern extreme of their pelagic range in the eastern Pacific, fur seals are rarely observed in waters with a surface temperature higher than 14°C. The warmest waters in which the species is known to have occurred is 15.5° which Hubbs recorded on February 4, 1950, between Guadalupe and San Benito Islands, Baja California.

Warm waters could impose considerable heat stress on *Callorhinus* during prolonged shallow dives, for the animals could easily experience difficulty in dis-

sipating the large quantity of heat produced by powerful and sustained swimming. Unlike the thin-pelaged northern elephant seal (*Mirounga angustirostris*), California sea lion (*Zalophus californianus*), and harbor seal (*Phoca vitulina*), all of which occur in the waters at the southern limit of the fur seal winter range, the northern fur seal, because of its fur, can lose heat rapidly only through its flippers. It is known that pinnipeds have efficient vasomotor control in their flippers and that peripheral vasoconstriction occurs during dives (Irving, 1939). The observation of Scholander *et al.* (1950: 235) on phocids that "... even a slight increase in the peripheral circulation could remove large quantities of heat generated by swimming," is equally applicable to otariids. In some circumstances it may be more important for pinnipeds to lose heat than to control levels of CO_2 and O_2 in the blood. Therefore peripheral vasoconstriction may not be maintained invariably during dives, particularly in furred forms such as *Callorhinus*.

From the discussion above it appears probable that the hind flippers of *Callorhinus* have a thermoregulatory function in the water. It appears reasonable to suggest that this thermoregulatory function may account for the relatively large hind flippers of *Callorhinus* as compared to the non-furred otariids. Sea lions such as *Zalophus* have a pelage that allows the skin to be wetted and therefore are not dependent exclusively on their flippers for losing heat. Therefore large hind flippers as a thermoregulatory mechanism might be favored by natural selection in fur seals, but not in their nonfurred relatives.

Relatively little is known of the body temperatures of pinnipeds. The resting temperature of the Alaska fur seal approximates that reported for *Phoca vitulina* and exceeds that reported for *Mirounga angustirostris*. The temperature of baby *Callorhinus* exceeds that of the adult just as in the elephant seal (Bartholomew, 1954). Data on body temperatures of otariids is scant. The rectal temperature of a one-week-old female California sea lion, *Zalophus californianus*, was 38.6°C. (Bartholomew, unpublished data); it is probable that the resting temperature of the adults is somewhat lower.

Pinniped body temperature is surprisingly labile considering that seals are among the larger mammals. Scholander and Grinnell (1942) showed that in a restrained specimen of *Phoca vitulina*, body temperature fell as much as 2.5°C. during a simulated dive. It was found (Bartholomew, 1954) that resting adult *Mirounga angustirostris* had a mean daytime rectal temperature of 35.9 and a mean nighttime temperature of 33.8°C. In the present study, the lability of the body temperature of *Callorhinus* is clearly demonstrated—intense activity may cause a rise of several degrees centigrade above the resting level. Nothing is known of the diurnal periodicity of the temperature of *Callorhinus*. There is no conspicuous diurnal cycle of behavior on the rookery. Activity appears to continue unabated during the short subarctic night. It is probable that diurnal changes in body temperature are negligible during the breeding season.

The level of copulatory activity sustained during the breeding season by male northern fur seals (Bartholomew and Hoel, 1953) is probably as high as that shown by any other mammal. As a result of their furious activities in harem

maintenance, territory defense, and copulation, the bulls frequently show signs of heat stress. In view of the demonstrated lability of fur seal temperatures there can be little doubt that the bulls often experience elevated body temperatures incidental to their reproductive activities. The well documented sensitivity of mammalian spermatogenesis to elevated body temperatures, the bulls' high levels of sexual activity, their proneness to hyperthermia, and the clearcut difference between scrotal and deep body temperatures in this species make the physiological utility of the scrotum as a thermoregulator particularly obvious. It is of interest that the resting temperature of at least some phocids approximates that of *Callorhinus*, but that phocids have abdominal testes. This underscores the observation of Wislocki (1933: 392) that ". . . the separation of groups on the basis of temperature in association with descended or undescended testes is not sharp but one of degree only." Phocids show only a limited activity on land and hyperthermia is probably rarely produced by their terrestrial locomotor activities. The possibility exists that the abdominal temperature in the immediate vicinity of the testes may be somewhat lower than that of the rest of the viscera, a situation that has been reported in laboratory mammals (Moore and Quick, 1924). Beyond this point discussion of the temperature differences associated with testicular location in pinnipeds appears futile at the present time.

SUMMARY

The evolution of a highly effective insulation of fur and blubber adapts the northern fur seal for occupancy of cold waters, but the very efficiency of this mechanism of heat conservation poses an acute physiological problem for the species during its terrestrial breeding activities. It places the upper limit of its zone of thermoneutrality at a remarkably low temperature (certainly less than 12°C.) and makes sustained vigorous activity on land impossible.

The bulls and cows at rest have a mean deep body temperature of 37.7°C. Pups have a mean rectal temperature of 38.2°C.

Under conditions of sustained terrestrial activity fur seal temperatures rise conspicuously. During the drives from the rookery to the killing grounds they may become overheated and die of heat prostration even though air temperatures are as low as 10°C. Body temperatures may rise as high as 43.9°C., but temperatures higher than 41.5 are found only in animals incapacitated by heat exhaustion.

The density of the pelage prevents effective heat loss except by the flippers and the respiratory system. The flippers, which are black and naked, and equipped with sweat glands, allow heat dissipation both by evaporation and by radiation. On land, heat loss is facilitated by vigorous fan-like waving of the flippers; in the water, heat loss is reduced by holding the flippers out in the air.

Bulls and cows frequently become overheated during normal activities in the rookery and often pant and wave their flippers. The pups are less well insulated and almost never show signs of heat stress. However, unlike the adults, they frequently shiver.

Scrotal temperatures are 6°C. or more lower than the deep body temperatures.

When air temperatures rise to as much as 12°C., or the overcast thins, the general level of the activity of the bulls decreases sharply and some of the females temporarily return to the sea.

The relation of temperature regulation of fur seals to their aquatic and terrestrial distribution, to flipper size, vasomotor activity during dives, and location of testes is discussed.

LITERATURE CITED

BARTHOLOMEW, G. A. 1954. Body temperature and respiratory and heart rates in the northern elephant seal. Jour. Mamm., 35: 211–218.

BARTHOLOMEW, G. A. AND P. G. HOEL. 1953. Reproductive behavior of the Alaska fur seal, *Callorhinus ursinus*. Jour. Mamm., 34: 417–436.

HANNA, G. D. 1924. Temperature records of Alaska fur seals. Amer. Jour. Physiol., 68: 52–53.

MOORE, C. R. AND W. J. QUICK. 1924. The scrotum as a temperature regulator for the testes. Amer. Jour. Physiol., 68: 70–79.

SCHOLANDER, P. F., V. WALTERS, R. HOCK, AND L. IRVING. 1950. Body insulation of some arctic and tropical mammals and birds. Biol. Bul., 99: 225–236.

SCHOLANDER, P. F., L. IRVING, AND S. W. GRINNELL. 1942. On the temperature and metabolism of the seal during diving. Jour. Cell. and Comp. Physiol., 19: 67–78.

WILKE, F. 1951. Pelagic fur seal research off Japan in 1950. Gen. Headquarters, Supreme Commander for the Allied Powers, Nat. Resources Sect., Prelim. Study No. 67: 1–35.

WISLOCKI, G. B. 1933. Location of the testes and body temperature in mammals. Quart. Rev. Biol., 8: 385–396.

Department of Zoology, University of California, Los Angeles, and Branch of Wildlife Research, U. S. Fish and Wildlife Service. Received October 6, 1955.

OBSERVATIONS OF WOLVES HUNTING CARIBOU

BY LOIS CRISLER

One of the interesting and unsettled problems about predator-prey relations concerns the degree to which predation is selective of the weak and the sick. Efforts to resolve this issue have suffered from lack of specific data. My husband Cris and I were privileged to watch many attempts of the Alaskan wolf (*Canis lupus*) to catch barren ground caribou (*Rangifer arcticus*). The purpose of this paper is to record some of our observations.

We camped in various parts of the Brooks Range of Alaska for 13½ months taking moving pictures of caribou and wolves for the Walt Disney Studio. Headquarters were shifted from time to time but our main base camps were three: first, at Noluk Lake near the head of the Colville River on the north front of the De Long Mountains; next, in the Alatna-Nigu-Killik Pass in the Endicott Mountains; and finally, on the Killik River about 25 miles north of this pass. We were in the field from April 15 to November 1, 1953, and from March 13 to October 14, 1954.

During this time we observed only 20 wild wolves. The number was comparatively small, as we saw great herds of caribou—at a rough guess, a hundred

thousand, of which thousands must have been repeats. The fewness of wolves may have been partly due to intensive wolf-hunting by the U. S. Fish and Wildlife Service the year of our arrival.

Movements of the caribou and wolves.—The caribou of northern Alaska winter mostly on the south side of the Brooks Range where adequate lichen range is available. In the spring they stream north not only through various passes but also, very impressively, in many places directly over the tops of the mountains and along the ridges, to summer in the mountain valleys and on the tundra. At our points of observation the migrations occurred as follows. In 1953, on the north front of the De Long Mountains, bands chiefly of cows, milling slowly both east and west from the time of our arrival, May 1, until May 26, had already crossed the mountains and were apparently established here on their late spring range. From May 31 until June 19 a migration of about 12,000 caribou, predominantly bulls in the velvet, passed here on a 10-mile front. The reversal into the mountains began about June 26.

On July 11, 1953, past our camp in a pass in the Endicott Mountains about 5,000 caribou went north in a winding column. Tracks indicated that these were the final section of a large migration. A year later, on July 12, 1954, at our camp 25 miles north of this pass, a grazing multitude of about 30,000 caribou passed going north on a two-mile front, between 2:00 PM and 11:00 PM.

The fall migration returning south across the mountains for the winter began passing this camp in a broken column on October 1, 1953, and on September 20, 1954, dwindling and ending respectively on October 15, 1953, and October 6, 1954. We witnessed the spring return of the caribou, filing north over the tops of the mountains and ridges on at least a five-mile front from March 29, 1954, until the middle of May. The files descended to cross our valley, then ascended again. As the valleys thawed they traveled lower. Between the two main spring, summer and fall migrations described, a great number of diversified movements of smaller groups occurred.

The wolves on the contrary appeared to be sedentary during our periods of observation. With young in the dens they did not follow the caribou herds but rather utilized them as they passed. We came to know most of the resident wolves. From May 1 until June 29, 1953, in the De Long Mountains, we occasionally saw one or both of an apparently mated pair. They denned about ten miles from our base camp. During this time we found only six dead caribou, of which two, we thought, were wolf kills. These were found fresh comparatively near the den as the final stragglers passed, after a main migration. The other four, ten miles from the den, may or may not have been kills.

At our camp in the pass we observed four wolves, two apparently resident and two, on July 30, passing through. At our final camp in 1953 we observed a lone gray wolf; a band of four—one black, two dusky, one gray; and a band of three gray wolves. Each time we saw any of these they were going east, as if they had a circuit that brought them past our camp occasionally.

Here in 1954 we found the den of a mated gray pair with five pups. Without otherwise molesting the parents, which were bounding around, we took the pups,

which we raised. We also observed a lone gray resident female and a band of three, one black and two gray.

The often described habit of wolves following the caribou about the country must be limited to the winter period, and our evidence suggests that the wolves return from their peregrinations to breed in their "home" localities.

Healthy caribou can outrun wolves.—There follow descriptions of a number of unsuccessful attempts of wolves to catch normal, healthy caribou.

1. July 30, 1953.—In a lake-sprinkled pass in the Endicott Mountains, about 8:00 AM, we saw two long-bodied, cream-colored wolves in the pass below us, idling northward. The caribou situation here at this time was that stragglers, either alone or in small groups, daily drifted in any direction through the pass, in the wake of a large grazing migration that had finished passing north on July 11. From eight o'clock until noon we watched these two wolves hunt.

First the wolves gave chase to a cow going north. The wolves and cow seemed to increase their speeds. Then the cow began to draw ahead. The lead wolf, the larger of the two, stopped, glanced back at the other wolf and sat down. The cow kept running and disappeared over the distant divide to the north. Typical was the wolf's prompt judgment as to when the chase had become futile.

The wolves now went to the west side of the pass, opposite us, where they pounced and dug as if hunting mice. Suddenly the smaller, more alert and determined wolf started back southward. (We thought it was a female, and for convenience I will call it so.) A young bull caribou was trotting north. The wolf ran past him, above, unseen, until she got behind him, then turned and galloped after him. He ran toward the big wolf, which waited to the north on the side of a spur above the end of a long lake.

As the bull passed below him, the wolf cut in on a right angle and hurled himself after it. The bull swerved down and crossed a marsh at the lower end of the lake, then ran on northward again. When the wolf hit the marsh he sank out of our sight, came into view for a few leaps, then gave himself up to a wallow. He emerged muddy.

The two wolves now trotted back southward to the lake just below us. All at once the smaller wolf broke into a run again. She put a big mature bull into the lake. He started swimming to our side. The wolves trotted down the far side of the lake and leaped through the ponds at its lower end. This cleaned the muddy wolf. They headed leisurely up along our side of the lake, following its ins and outs.

The bull reached shore on our side but stood quietly in the water, wasting precious time as the wolves drew nearer. He merely turned his antlers, looking this way and that, mostly northward, the direction in which he had originally been traveling. Not until the wolves were close did he look back and see them. Instantly he plunged back into the lake and started swimming diagonally across to its northwest corner. The wolves retraced their steps. It was a race, performed with deliberation. It looked as if wolves and bull would reach the northwest corner of the lake simultaneously. But as the wolves left the ponds and came

up on the far side of the lake again, they found themselves behind a cow and calf trotting north. The wolves stretched into a run after the oblivious caribou.

The bull neared land just as the two caribou were passing. The three animals startled each other. The bull turned once more and swam toward the center of the lake, the cow and calf broke into a run. The wolves were coming at a dead run. The calf left the cow, turned and ran up the mountainside, where rocks hid it from our sight. The cow hesitated, often pausing and glancing back, even circling. Finally she turned and ran steadily away to the north, over the divide. She and the calf had given the wolves considerable advantage but had left them easily when they felt impelled to get away.

The wolves apparently thought no more of the bull in the lake. They lay down in a moist green place. The bull trod water in the center of the lake for quite a while, then swam to our side. Again he did not come right out but stood motionless for a long time. When he did emerge, he stood still another long while, watching before lowering his head to graze.

We now went down into the pass and crossed west to a low mound separated by a narrow swale from the wolves, where my husband could photograph above the heat waves. The large male lay motionless. The female raised her head now and then to look at us and at last rose and lay down so she could watch us without lifting her head.

Suddenly she rose and started south. Another caribou was coming north along the west side of the lake. The male wolf sat up, looked at us, then walked sluggishly after the female but kept glancing back. The female, as usual, got behind the cow, then started the run, heading the caribou toward the male wolf. Once the caribou stopped and faced back, taking a look at her pursuer. The wolf immediately stopped also, and sat down. Our observation is that a wolf prefers not to be eyed when approaching its prey. The cow took off again, with the flying upward launch used now and then by frightened caribou. The wolf followed. The caribou was apparently running straight to death. She had not seen the waiting wolf.

At this moment the forgotten calf, as the cow passed near, jumped up from where it must have lain tight all this time. It ran as if to overtake the cow. The cow passed above the big wolf without seeing him. Knowing the speeds of the two animals we knew she was safe. The female wolf had stopped; the chase belonged to the male. He ran after the cow but gave up easily. Next he tried for the calf. It acted hesitant, pausing often to stare back at the wolf, which was rapidly gaining on it. Finally it did run steadily and overtook the cow—a feat of fleetness, for the cow was doing her best now, not hesitating at all. Apparently she was the wrong cow; again the calf turned and ran up the mountainside, disappearing permanently from our view. In spite of its vacillation, this two-month-old calf had overtaken an adult caribou by extending itself, and had left the wolf behind with ease.

The wolves now came over to look more closely at us. The male circled us, yawned and trotted away to the north. The female came directly up onto our mound, looked at us, then circled and followed the male away.

2. April 14, 1954.—During the spring return of the caribou in small bands from south of the mountains, a band of forty grazed in a hollow just below the top of a ridge. From another ridge two wolves spotted them and trotted down through a draw toward them, holding their direction though they could not see the caribou then. They trotted up the ridge and got behind the caribou before flushing them, so that the caribou ran our way. The wolves ran full speed. Gathered into a dense bunch, swerving as a unit, the caribou swept right under us with a rush-crush of hoofs in the snow, white ptarmigan rising in a V ahead of them. Then they were past and gone, on their migration direction toward the northwest. The wolves trotted, then stopped in the valley, completely and hopelessly outdistanced.

3. April 28, 1954.—During a walk from 8:00 AM to 4:00 PM we saw two wolves approach the top of a low rise and halt on seeing just below them about 14 caribou lying on a snow patch on a frozen lakelet. The wolves stalked, but without crouching, to within about 100 feet before the caribou noticed them and sprang up. Then the wolves gave chase. A wolf could hardly have had a better chance. But the caribou group left the wolves behind.

4. June 5, 1954.—At noon four bulls came east. Crossing the marshy tundra below me, and about 300 yards away, they sprang into a run. They had aroused two wolves sleeping in the marsh this hot day. The wolves chased but soon gave up. The bulls paused, then came directly back to where the two wolves stood watching. The wolves ran after them; the caribou split, two to the left, two toward the river, and these the wolves pursued. The bulls ran along the gravel bar, lashed into the water and swam across the river. The wolves ran along the bar too, but were soon outdistanced. They wet their feet but turned away from the current and gave up the chase.

Apparently a healthy caribou can give himself a considerable handicap, by hesitating, or because of being taken by surprise, and still easily get away. On July 17, 1954, at 4:00 AM we saw a bull running not forty feet ahead of a lone wolf. The bull jumped into a river and swam across. The wolf did not follow.

5. June 21, 1954.—In the June reversal of migration direction that follows the first intensely hot day of the year, one band of 250 caribou bulls—mostly old, some young—halted peacefully on the mountainside above our camp and lay down or grazed. Suddenly half of them banded for flight and started running back in the direction from which they had come. We spotted a lone wolf following them.

The caribou traversed the mountainside—its rises, its depressions, its rough rocks and brush—with the speed of a fast-flowing river and with the illusion of effortless unity and flowing that caribou give when running. They seemed to float across the mountainside. A couple of hundred yards behind them, the solitary tan figure of the wolf also drifted over the mountainside. The caribou drew ahead, leaving the wolf behind.

Incidentally I might say that the longest chase we saw a wolf make was for about five miles. There was no kill.

Wolves catching healthy calves.—A calf is more easily caught by wolves when

in a large herd than when alone, with its mother, or in a small band. Although calves can out-distance a wolf if they are in a small group or alone, when wolves get into a large herd of caribou, the commotion is so confusing that the calf apparently cannot tell that a wolf is near it until the wolf comes from behind some other caribou and is right beside the calf. The calves do not sprint but merely keep the speed of the caribou nearest them.

On July 12, 1954, between 2:00 PM and 11:00 PM, a herd of about 30,000 caribou passed us on a two-mile front, in grazing "formation." They crossed a river near us. In any large river crossing, some caribou get detached from their own group, that is, lost.

About 10:00 PM we saw a lost calf searching frantically. Its color was an unusually bright tan. Once, in a spot free of other caribou, it rotated in a wheel, bounding up on each turn, to look. Two wolves chased it but the tan calf left them behind. It was still around the next morning. Right after this failure by the wolves, they entered a large sector of hundreds of caribou resting or grazing in the willows by the river. In the next half hour the male wolf killed four calves. The female came up and nosed each kill. They stood over the first kill a few minutes, then ran on, putting the caribou multitude to flight. The wolves ran in the midst of them. The outlying caribou fell in behind them and passed them. The wolves never changed their gait; probably they could not accelerate to any faster pace.

Two of the calves, not completely dispatched, left their bloody beds in the sand and plunged into the river. One we never saw again. The second was found a few days later, partly eaten by wolves, where it had drifted ashore. The wolves returned on the night of the kills and ate the third calf almost entirely. The fourth kill was untouched the next day when we went to it. Its mother had returned and was loitering near it. When put to flight by our approach she first went to her dead calf as if expecting it to flee, too. (There is a noticeable return of cows searching for lost calves that have either been killed by wolves or lost from their mothers.) We did not return to see whether the wolves ate this calf later or not.

Crippled caribou.—The caribou the wolf catches is usually the caribou that slows down. Most of the caribou we have seen wolves chasing were healthy enough to run away. In every chase we have seen, it was apparent within a minute or two after the actual chase began whether a caribou would be caught or not. Usually, as I have said, a band swerves and runs as if it were one object with many legs. But a caribou that is subsequently caught loses the speed of the band almost immediately. Sometimes it takes its own direction, not trying to follow the band.

We saw evidences of several kinds of impairment that could cause a caribou to slow down. On July 24, 1953, our attention was first strongly attracted to limping caribou, although we had seen a few in May and June. But on this day the caribou bands were on the skyline above us. This was at the beginning of the short period of intense heat in July, when the caribou go high, if possible. Silhouetted against the sky were deeply limping caribou, their heads going away down, then up on every step. We called them "rocking-horse caribou."

In September, 1953, it was recognizable rocking-horse caribou that made us realize that bands passing camp from opposite directions, at intervals of a few days, were the same bands. This slow swirling, we discovered, is an indication that the main migration itself will come this way soon, when the fall trek southward across the mountains begins.

At noon on October 1, 1953, the main herd began passing our camp in the broken column formation of the fall return to the southeast, over the mountains for the winter. The caribou passed in diminishing numbers that night and the next day. For several days stragglers passed, alone or in bands.

The first day, Cris stationed himself with his camera by the half-frozen river at one of the crossing points the caribou were using. He noticed about twelve with "broken legs"—that is, rocking-horse caribou, including three at one time, near together: a bull, a calf and a cow.

We were not trying particularly to count the cripples. At my station on a hill, I made a few notes in my pocket notebook of crippled cows, calves and bulls, and the general comment: "If that rhythm of the legs is off, how one's eye flies to it."

Two typical examples of comments in my notebook:

1. With the main herd. On October 2, a cow came through alone with her calf. "The calf's head bobbed to its knees. The cow stood still looking keenly ahead after the distant herd. Then she turned her head looking back at the calf. She gave a small reedy grunt to it, turned and trotted fluently ahead. The calf walked, bobbing its head up and down. Presently the cow waited for it again."

2. With the stragglers. The morning of October 4, no caribou passed except "a calf with a lone pretty cow that had sharp little antlers and a white cape. The cow could hardly walk. Her right front leg was a stump used like a peg. The calf trailed slowly along behind her. She toiled along the migration route, stopping once to raise her head, ears forward, and look off ahead as if trying to see the herd."

The final animal seen on this migration was a cripple. The night of October 7–8, four inches of fresh snow fell. After this no more caribou tracks appeared over tundra or mountainsides. On October 9 we noticed a motionless small animal regarding us. It was a caribou calf. When it started to run from us we saw that one hind leg was as if broken. It laboriously got across a frozen lake from us, then resumed the migration direction. Its left hind hoof barely printed the snow. On October 15 the blood-stained hoof tracks of about 10 caribou were seen.

The following year, in 1954, the fall migration began passing us on September 20 and continued, *diminuendo*, till October 6. There were some cripples with the main migration but more at the close. On the first day (September 20) I noted a bull with a "broken" hind leg—a rocking-horse bull—with a small band of cows following him; they stopped when he stopped. Also a cow with two calves (not necessarily both hers), one of them with a dislocated or "broken" front shoulder; it stuck out. Also a cow holding one leg stiff. This general notation was made that day in my pocket notebook: "At the close came the cripples. Last of all, a crippled cow making on alone, all the others long out of view." As

TABLE 1.—*A tally of straggling caribou that passed our camp between September 21 and October 6, 1954, showing the incidence of crippled and sick individuals*

Date	Bulls	Calves	Cows
Sept. 21, 1954	10	10	14
	1	2	2 (2 crippled)
	15	11 (1 crippled)	14
	14	9	14
	2	5	10
		5	8
	10	10	14
		1	2
		4 (1 crippled)	12
	8	8	19
		24	40
	15	16	47
		3	7
		1 ("tired")	1
	1 ("slow")		2 (1 with diseased lungs)
Oct. 6, 1954		2	5
	76	110	211
Per cent visibly impaired	1.3	2.7	1.4 = Average 1.8

usual, a few stragglers kept coming through until October 7, when the final few (five cows and two calves) passed.

On October 1, walking back along the migration route, we found a calf freshly killed by wolves and partly eaten. One hind hoof was a balled-up clump with raw red ankle. The next day we found another freshly killed calf, also with a swollen clump hind hoof. From my pocket notebook: "This calf had one hind foot injured or diseased. The chiton half off one side. Raw stump exposed. Old 'wound', rough. The nail grown out long from the hair." A day or two later we found a third fresh, wolf-eaten calf a mile or two farther back along the migration route but could not find the hoofs.

From September 21 through October 6 we counted the numbers and kinds of stragglers passing (Table 1). Of 397 strays that came by, mostly in small groups, there were seven visibly impaired individuals—one bull, three calves, and three cows. Presumably these animals, constituting 1.8 per cent of the stragglers, were particularly vulnerable to wolf predation.

Caribou presumably could become crippled in a number of ways but one definite possibility is in falls on slippery ice. We saw many caribou skid and a few fall in crossing frozen rivers in their migration course. One yearling could hardly walk after a fall. Often the cow in the lead of a small band would start across, skid, then halt and stand as long as ten minutes, looking ahead across the ice, while the group behind her waited. She would return to shore and walk along till she found a better place, for instance where a sand-bar reached part way across the river. The group would follow her.

After one difficult ice crossing, first shunned, then attempted, black pellets were dropped for a hundred yards on the far side, apparently by every member of the band, perhaps an indication of tension felt during the crossing.

Diseased and "tired" caribou.—It was only as I read my notes later that the numbers of "tired" calves mentioned impressed me with the possibility of disease rather than tiredness. These "tired" calves were not visibly crippled.

For example, on September 22, 1954, "a nimble gray cow came through alone, with a tired calf. She would speed ahead, her trotting hoofs meeting underneath her, her back limber. Presently her head would turn a little, uncertainly. Then she would stop, look back and wait till the calf, doggedly and slowly trotting, was almost up to her, then she speeded ahead again."

Incidentally, we saw good reason for a calf to be tired on June 26, 1953, when two cows with a baby calf, probably less than a month old, passed, trying to keep up with a band of about sixty bulls, mostly mature. The bulls swung along on the relentless migration trot. Two hundred yards behind galloped the two cows and the calf. Also on that day we saw an abandoned calf on the tundra. It tried frantically to join any cow that passed. One cow reared up and struck at the calf and ran, veering erratically, till the calf, following her desperately, finally collapsed, exhausted. That evening a cow returned alone from the migration direction, perhaps seeking this calf.

On September 29, 1954, two two-year-old caribou cows came through together. When surprised by a wolf, one ran lightly away. The other ran, but remarkably slowly. Five wolf puppies that we were raising lumbered after it, single file. It turned and faced them and sank on one knee, then lay down. Hesitatingly the small wolves surrounded it. It got up and ran. Then, untouched, it faced and voluntarily lay down again. Cris examined it later. Its lungs were partly deflated and contained eight abscesses, some as big as pingpong balls, half buried in the tissue and full of watery fluid. They seemed to be tapeworm cysts.

We saw a "slow" bull killed by a lone sled dog the following day. This dog was smaller and considerably slower than a wolf. Though the chase lasted perhaps a mile, including a circling return by the pursued bull, it was apparent from almost the first moment that he had no speed.

"Slowness" in the caribou might be induced by nose bots. On June 10, 1953, we found a small caribou dead with masses of red maggots in the nose. Certainly the flies attempting to deposit eggs in the caribou's nostrils were a serious bother to the animals. On June 19, 1953, we watched solitary bulls standing on scattered snow banks in the mountains, each holding its nose to the snow. One would lie down as if tired and wanting to rest but would jump up at once and hold its nose down to the snow again. Once three such bulls were in view at once. On June 26, 1953, we saw calves and cows on a snow patch shaking themselves and holding their noses to the snow. During and after the intense hot spell of July we saw "crazy" caribou, running erratically, presumably to escape the nose flies.

Summary.—It appears to us that wolves have great difficulty catching healthy

adult caribou, and even calves are not often overtaken except in the confusion of a large herd.

At least half of the kills that we observed involved crippled or sick caribou, whose incidence is in the neighborhood of 1.8 per cent among stragglers and even lower among the main herds. Presumably, therefore, predation was highly selective for unhealthy individuals.

Crag Cabin, Lake George, Colorado. Received December 9, 1955.

GRAY FOX REPRODUCTION, DENNING, RANGE, AND WEIGHTS IN ALABAMA

By Edward G. Sullivan

One has only to scan any general bibliography of mammal studies to observe that a large number of investigations have been conducted on the red and gray foxes. Particularly impressing was the large number of food habits investigations reported. It was noted that far more studies have been conducted on the red fox than on the gray, particularly from the standpoint of physical characteristics, breeding, and range of activity. For the Southeast, relatively few references were found on physical characteristics of the gray fox. Very little information is available on results of tagging or banding gray foxes. No reference could be located on spermatogenesis in the gray fox.

This paper reports the findings of an investigation on breeding, denning, and range of activity of the gray fox, *Urocyon cinereoargenteus*, in Alabama. The material is taken from a thesis submitted in partial fulfillment of requirements for a Master of Science Degree in Game Management at Alabama Polytechnic Institute, Auburn. For field expenses and equipment for the study I am indebted to the Alabama Cooperative Wildlife Research Unit which is jointly supported by the Alabama Department of Conservation, U. S. Fish and Wildlife Service, Wildlife Management Institute, and the Alabama Polytechnic Institute Agricultural Experiment Station. I am grateful to Dr. Arnold O. Haugen, Leader of the Unit, who suggested the study, provided guidance, and assisted in preparation of this manuscript. The cooperation of Mr. T. J. Gleaton of the Alabama Department of Conservation, who provided many of the live foxes for examination is sincerely appreciated.

Materials and methods.—A total of 117 gray foxes, 58 males and 59 females, were examined over a period of 15 months extending from October, 1952, to December, 1953. Data on weights and measurements of some of these foxes were excluded due to the condition of the animals when obtained or to the fact that accurate measurements were impossible on live foxes that were to be released in the range study. As many of these foxes as possible were brought into the laboratory alive and examined immediately after killing. Foxes handled in this study were trapped by the investigator and the State Conservation Department Predator Control Agent.

The animals were taken in No. 2 Victor Coil Spring steel traps having the insides of the jaws rounded with a file and then wrapped with adhesive tape to lessen the amount of injury to trapped foxes. Severe injury was seldom inflicted to a fox taken in traps altered in this manner. Foxes released for the range study were tagged with a metal ear-tag (National Band and Tag Co., No. 1005, size 4) and released at the capture site. A number was also tattooed on the inside surface of the ear of some foxes.

Foxes brought in alive were killed by placing their head in an ether cone until unconscious and then pressing in the chest region. They were then weighed to the nearest ounce and measurements of total length, tail vertebrae, hind foot and ear were made. The uteri of the females were examined and observations on breeding condition were made, including counts of placental scars and fetuses. Within a few minutes after the death of male foxes, the testes were removed and examined for sperm. A smear was made from the epididymis, diluted with a drop of physiological salt solution, and examined.

RESULTS AND DISCUSSION

The breeding season.—Sheldon (1949) gives the breeding season as mid-January to May with the highest percentage mating in early March. Schoonmaker (1938) witnessed a pair of gray foxes copulating on February 3, in Albany County, New York. Seton (1929) states that the gray foxes are born in mid-April in the North and mid-March in the South. Hamilton (1943) mentions latitude as a factor in the gray fox breeding season.

It appears that the peak of the mating period for gray foxes in Alabama is reached in February. The first indication of breeding was on February 14, at which time a female in oestrus was trapped. All females handled prior to that date showed no signs of being in oestrus and examination of their uteri showed no evidence of having been bred. Two other females in oestrus were handled on February 20, and another autopsied March 2 was in very early stages of pregnancy. During the period March 3, to April 3, seven females were autopsied, all of which were pregnant.

Lactating females began showing up in mid-April and no pregnancies were observed after April 24. The period of May, June and early July showed most females lactating. A lactating female was examined July 31, and still another as late as August 7, which would indicate later breeding in some individuals. By mid-July, however, the condition of the mammary glands indicated that most females had weaned their young.

Of 31 females examined during the breeding season, two had not bred. Both these females were examined during the period when all other females were either pregnant or lactating. Sheldon (1949) found three barren gray females out of 90 handled.

Spermatogenesis.—Bishop (1942), working with silver foxes, found that the males contained active spermatozoa in late November and as late as the middle of April. Asdel (1946) states that spermatogenesis begins in November in the

red fox and the male is fertile 8 to 10 weeks before the breeding season. No reference was found on spermatogenesis in the gray fox.

A study of the male gray fox breeding cycle was begun in mid-February. From that time until April 24, viable sperm were present in all testes examined. Of four males examined April 24, only one showed viable sperm. Males were examined throughout the summer and fall and viable sperm were not present in any of them until November. Three males examined November 7, were without mature sperm. One of four foxes examined November 13, contained viable sperm. Testes of all foxes examined after that date showed an abundance of sperm.

The above evidence indicates that male gray foxes in Alabama are fertile from mid-November to mid-April. This coincides with the fertile period in ranch-raised silver foxes according to Bishop (1942).

Litter size.—Sheldon (1949) reports that gray foxes in New York have an average litter size of 3.66, with a variation of one to seven. Three to five is the number given by Seton (1929) as well as by Frye and Lay (1942). Working in Pennsylvania, Latham (1943) found the normal gray fox litter to consist of from four to six young.

Twenty-six females were examined from which data on litter size could be obtained. Only those pregnant or those in which placental scars could definitely be observed and counted were considered in gathering data on litter size. Placental scar counts could be readily made on gray foxes until October. For a few weeks after parturition, and while the uterine horns were still enlarged, placental scars appeared as darkened, almost black enlargements. After the uterine horns had shrunken to normal size, about 4 to 5 mm. in width in females that had borne young, placental scars appeared as small enlargements and were more red than black. As the season progressed, the placental scars gradually became more difficult to detect. In a female examined September 11, placental scars were barely distinguishable as very pale pink spots in the uterine horns. By pulling the uterine horn between the thumb and forefinger, a very small enlargement could be felt at each placental site. By the first week in October it was impossible to make placental scar counts with any degree of accuracy.

The over-all litter size based on embryo counts in six females and placental scar counts in 20 females was 3.84. The average based on embryo counts alone was 4.16 and on placental scar counts 3.80. Litter size ranged from one to five with four young being found in 14 of the 26 litter sizes counted.

Denning habits.—The gray fox apparently is not very particular in choosing its denning site nor very careful in preparing a den. Latham (1943) found gray fox dens in all sorts of locations such as scrap piles, brush piles, under old houses, and in burrows of other animals. Frye and Lay (1942) found most gray fox dens in Texas in hollow logs or holes among rocky ledges, but they state that the gray fox sometimes digs its own burrow. Moore (1949) describes a gray fox den observed in Florida in an abandoned gopher tortoise burrow.

Gray fox dens located in this investigation were in a variety of situations. As a rule, all dens were located in more dense cover and were much less conspicuous

than is usually the case with red fox dens. This made the task of locating dens a very difficult one. Of interest also was the fact that all dens observed were located near a permanent source of water. One den was 20 feet from a stream, another less than 100 yards, and all others less than one-fourth mile.

Slab piles, which are found around most abandoned sawmill sites, were a favorite site. Three of the eight dens observed were in slab piles. Fox hunters interviewed during the investigation stated that they had seen numerous gray fox dens in slab piles and that foxes often take refuge in these slab piles while being chased by hounds. Sawmill sites are listed as a favorite denning site for red foxes in Alabama by Pearson and Herbert (1940). They burrow into the sawdust, sometimes having a dozen or more entrances facing different directions around the pile. No case was observed where a gray fox had actually dug a den in sawdust, but one gray fox den was found in an abandoned red fox den in a sawdust pile. This was known to have been an abandoned red fox den since the investigator observed it the previous year while it was occupied by red foxes.

Other den locations were in hollow logs and in a cavity under rocks. Only two dens were actually underground. One of these was in what apparently was a red fox den of a previous season. The other ground den was at the base of a rotten stump. The fox had merely enlarged an opening where one of the tree roots had rotted away. No gray fox den was observed that had required an extensive amount of digging.

Movements of wild gray foxes.—Sheldon (1953) got returns on two female gray foxes, both banded as juveniles. One of these was banded October 15, 1947, and trapped November 21, 1947, 11 miles from the banding site. The other banded October 20, 1947, was trapped in February of 1950, 52 miles from the banding site.

During the course of this investigation, 27 gray foxes, some juveniles and some adults, were tagged with metal ear-tags. All of these foxes were taken in steel traps. Only three of these (all females) have been recovered to date. Two of these foxes (adults) were retaken at one-fourth (tagged Dec. 17, 1952—recovered Dec. 19, 1952) and one-half mile (tagged Nov. 11, 1952—recovered Nov. 26, 1952) distances. The third had moved 4½ miles during its first winter as a juvenile (Sept. 9, 1952–Feb. 14, 1953), and was then shot only one mile from its second point of capture when it was approximately 2½ years old (Dec. 28, 1954). Even though the project was given publicity by radio, newspaper and personal contact with fox hunters, and a reward was offered for the return of a tag, only a single tagged fox was reported other than the ones recaptured by the investigator. The lack of reports from sportsmen and farmers is probably due to the fact that foxes are seldom trapped in Alabama. Fox hounds occasionally kill gray foxes, but since their fur was practically worthless at that time, the hunters apparently did not bother to pick up foxes killed by dogs.

Weights and measurements of adult gray foxes.—The weights of 71 adult gray foxes taken at all seasons are presented in Table 1 by sex and season. Included in these weights are only foxes that were freshly killed or foxes that were weighed alive and released in the range study. Weights are not included for many of the

TABLE 1.—*Average weight in pounds of adult gray foxes by sex and season*

Season	Female			Males		
	Av. wt.	Variation	No. examined	Av. wt.	Variation	No. examined
Spring	8.1	7.4 to 8.8	8	8.2	7.2 to 9.2	11
Summer	7.2	6.2 to 8.5	6	7.6	7.0 to 8.5	5
Fall	7.7	6.2 to 9.2	11	8.6	6.8 to 11.2	9
Winter	7.7	6.7 to 9.0	9	8.2	7.4 to 9.5	12
All seasons	7.8	6.2 to 9.2	34	8.2	6.8 to 11.2	37

TABLE 2.—*Measurements in millimeters of adult gray foxes*

Sex	Total length av.	Variation	Tail vert. av.	Variation	Hind foot av.	Variation	Ear av.	Variation	No. examined
Male	921	820 to 983	336	280 to 365	138	118 to 155	69	63 to 75	44
Female	894	821 to 940	332	287 to 360	132	126 to 142	68	62 to 74	43

foxes examined because they were held in cages several days before autopsy. The heaviest fox examined in the investigation was a fall-caught male that weighed 11.2 pounds. Both males and females were lighter during the summer than at any other season. Females averaged heavier during spring, due probably to the fact that several were pregnant. Males averaged slightly heavier and larger by measurements than females (Table 2).

Sex ratios.—The over-all sex ratio for 117 gray foxes handled was 98 males per 100 females. There was a marked seasonal difference in sex ratios of trapped foxes. Spring and fall catches showed an even distribution of sexes, but the summer catch showed a preponderence of females while the winter catch showed more males than females.

Summary.—Reproduction, denning, range and weights of Alabama gray foxes, *Urocyon cinereoargenteus*, were studied. A total of 117 foxes was examined. Evidence indicates that the peak of the mating season is reached in February. The male gray fox is fertile from mid-November to mid-April. The average litter size for gray foxes is 3.8, with a variation from one to five young per litter. Dens were found in slab piles, hollow logs, under rocks and in the ground. All dens were within ¼ mile of water. Returns of three tagged foxes, one of which was retaken twice, showed distances of capture site of ½, ¼, 1, and 4½ miles. The average weights of gray foxes were: males 8.2 pounds and females 7.8 pounds. The heaviest fox handled was a male weighing 11.2 pounds. Average measurements are given.

LITERATURE CITED

ASDELL, S. A. 1946. Patterns of mammalian reproduction. Comstock Publishing Co., New York.

BISHOP, D. W. 1942. Germ cell studies in the male red fox. Anat. Record, 84: 99-111.

FRYE, O. E. AND D. W. LAY. 1942. Fur resources and fur animals of Texas. Game, Fish and Oyster Comm. Bul. 25.

HAMILTON, W. J., JR. 1943. The mammals of Eastern United States. The Comstock Publishing Co., Ithaca, New York.

LATHAM, R. M. 1943. An ecological study of the red and gray foxes in Southeastern Pennsylvania. Report of P-R Project 1-R, Pennsylvania Game Comm.

MOORE, J. C. 1949. Putman County and other Florida mammal notes. Jour. Mamm., 30: 57–66.

PEARSON, A. M. AND J. E. HERBERT. 1940. Sly b'rer fox has many entrances to his den. Ala. Conservation, 1(2): 9.

SCHOONMAKER, W. J. 1938. Notes on mating and breeding habits of foxes in New York State. Jour. Mamm., 19: 375–376.

SETON, E. T. 1929. Lives of game animals, Vol. 1, Part II, Doubleday, Doran and Co., New York.

SHELDON, W. G. 1949. Reproductive behavior of foxes in New York State. Jour. Mamm., 30: 236–246.

SHELDON, W. G. 1953. Returns on banded red and gray foxes in New York State. Jour. Mamm., 34: 125.

South Carolina Wildlife Resources Department, Box 360, Columbia, S. C. Received October 19, 1955.

PRELIMINARY STUDIES OF THE KIT FOX IN UTAH

BY HAROLD J. EGOSCUE

The kit fox, *Vulpes macrotis nevadensis* Goldman, is perhaps the least known of the Canidae found in Utah, and most of the Utah literature on this animal is concerned with taxonomy and distribution. In his revised account of Utah mammals, Barnes (1927) listed the kit fox as *Vulpes velox velox* and commented on its abundance in the state. Fautin (1946) mentioned it as a major influent in the northern desert shrub biome in western Utah and included some observations on food habits. Durrant (1952) mapped the kit fox distribution for the state and listed Utah specimens examined by him as referable to *Vulpes macrotis nevadensis.*

This paper presents the results of a kit fox study made from July, 1951, to July, 1955, in south-central Tooele County, Utah. More specifically, the study area includes the desert valleys bounded on the west by Granite Peak, on the northwest by the salt flats of the Great Salt Lake Desert, on the northeast by the Cedar Mountains, and on the south by Simpson Mountain and the north end of Dugway Mountains. Elevations along the valley floors range from about 4,300 feet to 4,800 feet.

The principal aim of this study was to determine the natural involvement potential of the kit fox in the epizoology of endemic diseases in the area. In this respect the food habits and host-parasite relationships are of prime importance.

Many members of the staff of Ecological Research, University of Utah, gave assistance or made useful suggestions during this study. Acknowledgment is given to E. A. Shippee for permission to use his unpublished data; to E. Ekker, B. N. Day, J. Smith, W. J. Bacha and E. M. Rosasco for assistance during various phases of the field work; and to C. Jorgensen who identified the specimens of *Ixodes texanus*, which were confirmed by G. M. Kohls of Rocky Mountain Laboratories, Hamilton, Montana.

Methods and procedures.—Most live foxes collected during this study were trapped in No. 7 special Havahart fox traps equipped with a detachable live bait compartment. The live bait compartment also proved useful for transporting foxes from the field to the laboratory and eliminated carrying the entire trap back and forth each time a fox was caught. Other Havaharts such as No. 3 and an improvised trap made by wiring two No. 2's together were also used but were generally deemed to be inferior to the No. 7 for trapping kit foxes alive. Traps were usually set in the immediate vicinity of the den.

The forty kit foxes examined included four specimens killed by cyanide guns on a cooperative predator control line established by the U. S. Fish and Wildlife Service.

Field notes made during this study included observations on: (1) live foxes, mostly in the immediate vicinity of dens; (2) tracks; (3) scat and urine stations; (4) food remains about den entrances; and (5) habitat preferences. One den was excavated.

Foxes were brought into the laboratory where they were processed for fleas, weighed, and ear tagged. During the flea processing, the shorter fur around the head, neck and ears was agitated by blowing into the fur, which seemed to disturb the fleas, causing many to move to the tips of the hairs where they could then be more easily removed with an aspirator. Fleas were also collected by enclosing all of the animal, except the head, in a bag and then introducing CO_2 gas into the bag. About three or four minutes later fleas would begin moving toward the tips of the hairs or would leave the host. Exposure to CO_2 for less than five minutes produced no mortality in the ectoparasites. After sterilizing the ears with alcohol, numbered sheep tags were fastened to the outside edge near the base of the left ear of the females and the right ear of the males. All data pertaining to the animal that might be of future value were recorded at this time.

Description.—Descriptions of adult kit foxes published by Barnes (1927), Grinnell, Dixon, and Linsdale (1937), Hall (1946), and Durrant (1952) suffice for adults of this area. Regarding the muzzle color so often mentioned as a taxonomic character separating subspecies, it has been noted that kit foxes of this area show an amazing amount of variation. Adult foxes varied from no black or brown on the muzzle (one individual) through shades of brown to black.

Since a detailed description of young foxes of the subspecies *nevadensis* has not been found in the literature, the following description based on three one-month-old individuals is included here: Body covered with short, woolly, puppy fur with distinctly longer, black guard hairs showing through the brown fur on back and hips; fur very reddish about shoulders and front legs but lacking black guard hairs; dark area on muzzle pronounced; tail greyish black with brown undertone darkest on tip, not bushy; underparts white; ears and muzzle relatively shorter than adults; eyes gray-blue as opposed to yellow-brown eyes of adults, pupils elliptical as in adults; average weight 575 grams.

Environmental responses.—Ecologically speaking, kit foxes of this area lead a dual existence. About eighty per cent of the dens were found in sparsely vegetated shadscale flats. Here the vegetation averages eight to ten inches in height

and is usually composed of the following principal species in order of importance: (1) shadscale, *Atriplex confertifolia*; (2) grey molly, *Kochia vestita*; and (3) ink weed, *Suaeda torreyana*. The low vegetation permits good visibility and the foxes find easy digging in the silty clay soil. Since these dens are located in an area of vegetation with low productive capacity for prey, the foxes must often travel as far as a mile to vegetated dunes or foothill communities where hunting is more profitable. The dunes support a mixed vegetation usually dominated by four-winged salt bush, *Atriplex canescens*, and rabbit brush, *Chrysothamnus* sp.

A permanent water supply apparently is not necessary. Many dens were located miles from permanent water. This led to the conclusion that moisture requirements must be satisfied by food. However, under laboratory conditions kit foxes drank water regularly.

It would seem that this animal is specifically adapted to arid conditions and in many ways is the North American counterpart of the fennec of the North African deserts.

Movements.—Kit foxes are almost entirely nocturnal. Hunting is usually done after dark, and daytime activity is confined to the immediate vicinity of the den.

In Death Valley, California, Grinnell, Dixon, and Linsdale (1937) gave the maximum distance kit foxes foraged out from the dens as two miles. In this area, most dens were less than one mile from vegetated dunes supporting relatively high rodent populations. Collection records and numerous observations of tracks and other signs lead to the conclusion that kit foxes regularly hunt in dunes close to the home dens. Nightly movements must vary considerably with the seasons and rodent abundance.

On several occasions, dens where pups were being reared have been suddenly abandoned by the entire family, usually after the pups were half grown. There are two possible explanations: (1) There may be a local depletion of the food supply, since demands made by six or seven kit foxes on the rodent and rabbit populations must be great; and (2) Dens may become untenable because of a build-up of ectoparasite numbers. Variation in the flea infestation of kit foxes was observed throughout the year without finding indication of seasonal periodicity.

Tracks made in the snow during December and January indicate that kit foxes visit dens and den sites not currently in use. This could be a survey of available dens, or it could represent a search for prospective mates by unpaired individuals.

An adult female that had been kept as a pet and could be identified easily by a heavy leather collar around her neck, demonstrated what is thought to be a hitherto unrecorded homing instinct for kit foxes. She was recaptured in the original home den area approximately twenty miles from where she escaped.

While suckling very young pups, female kit foxes spend most of their time in their dens At this time none were trapped although males were taken with little difficulty. This suggests that males do most of the hunting during this period.

A young fox tagged seven miles south of Wig Mountain in July, 1955, was killed by a U. S. Fish and Wildlife Service cyanide gun (coyote-getter) in Skull

Valley in September, about 20 miles from the point of tagging. This indicates widespread wandering of some young foxes. An adult male tagged on March 29, 1954, was found dead on February 6, 1955, along a road where it had been hit by a vehicle. This location was about one-half mile from the den where it had been captured the previous year. This indicates residence in a given area for at least one year. Twenty-eight kit foxes have been tagged to date.

Breeding habits.—Field observations and trapping records in the area indicate that kit foxes are usually monogamous, the pairs remaining together throughout the year. It is believed that this relationship may last indefinitely or until the death of one of the pair, whereupon the survivor seeks a new mate. On only two occasions were two lactating vixens found occupying the same den site. In one instance, one vixen was a much older animal than the other, suggesting a mother-daughter association. This type of association is believed to occur occasionally in coyotes (Young and Jackson, 1951).

The breeding season is early, beginning about the first of January. When breeding, kit foxes couple in the same manner as other canines. A pair was observed mating alongside a surfaced road about 8:30 PM on January 8, 1955. About two hours later a coupled pair (presumably the same) was again seen at the same location. The female of a pair kept captive in 1951 gave indications by her behavior in the presence of the male that she was in heat in late December.

In western Utah, most pups are born during March or possibly early April. Small pups, judged to be about one month old, have been captured or observed about den entrances during the last week in April and the first week in May. Some families remain together until about the middle of September. Litter sizes for this area are surprisingly constant. All litters observed during this study consisted of four or five young.

Dens.—Observations in this area show that kit foxes have definite den preferences. The general fox population density at any one time appears to be an important factor in determining how many den sites are occupied. One den area of about two acres had several dens in various stages of use and disuse; probably a favorite den site that had been used by many generations of foxes. Another site was occupied in 1951 and again in 1954, while another was occupied for three consecutive years (1952 through 1954) by three different pairs of foxes. At sites where only one den is available, it is used repeatedly. Where there is a choice of two dens, alternate use may be made of each. This study revealed no clear-cut examples of freshly excavated dens at previously unoccupied sites.

An area with a den already present is clearly more attractive than one where a den must be excavated. A den located about 150 feet from a group of office buildings and laboratories was occupied for three consecutive years during all or part of each whelping season. One notable exception was a culvert selected as a den where a litter of pups was reared in 1953. Most dens were in shadscale flats along the desert valley floors; none was found in the foothills or alluvial fans. All dens examined had two to five entrances, usually three. Typically, at least one entrance has a narrow ramp-like mound of dirt extending five to eight feet from the mouth of the tunnel. Dens constantly or frequently used are reno-

vated either by new occupants (in the case where an empty den is reoccupied) or renovated at intervals by the occupants, so that dirt eroded from the ramps by weather or compacted through constant use is periodically replaced. Old dens that have not been used for some time can be recognized by their weathered appearance. The den illustrated in Figure 1 is a typical three-entrance den. Practically all of the branch tunnel floor from entrance B to the junction with the intersecting tunnel was littered to a depth of three to five inches with animal remains and scats. The other section of the burrow was relatively clean.

Shallow forms (Fig. 1) partially under or alongside shadscale or other small bushes located within easy reach of den entrances are typical features of most

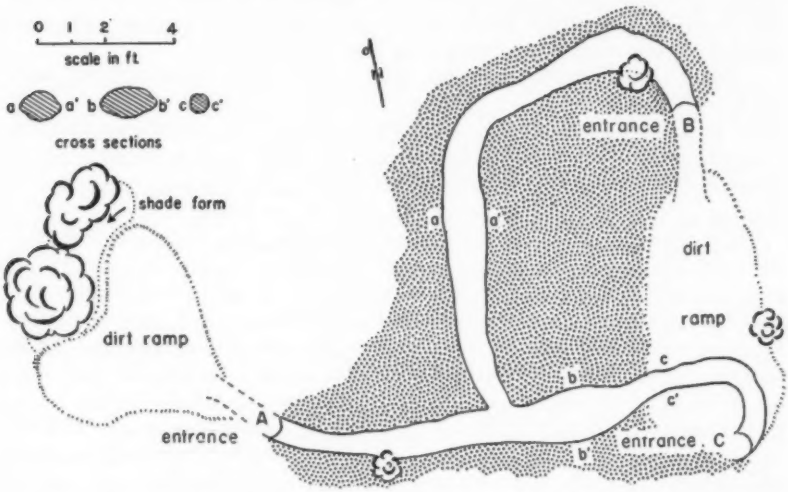


FIG. 1.—Diagram of a three-entrance kit fox den showing cross sections, entrance ramps, and shade forms.

fox dens in this area. Here foxes "shade up" during times spent above ground in the warmer parts of the day.

Animal associations.—PREY SPECIES.—Quantitative or qualitative kit fox food habit studies based entirely on prey remains from dens may give a distorted picture concerning pressures exerted by kit foxes on small rodent numbers. A complete scat analysis should improve our understanding of this phase of kit fox biology. Captive kit foxes ate entire carcasses of mice and kangaroo rats which may explain why small rodent remains in and around fox dens were seldom found. More commonly noted were wings and legs of birds, feathers, fur and the larger bones and feet of rabbits. Diurnal mammals such as the antelope squirrel and least chipmunk presumably would be of much less importance in potential food chains involving kit foxes than the many nocturnal species.

The following vertebrate and invertebrate remains from kit fox dens and scats have been identified thus far: black-tailed jackrabbit, *Lepus californicus*; kanga-

roo rat, *Dipodomys ordii*; deer mouse, *Peromyscus maniculatus*; burrowing owl, *Speotyto cunicularia*; horned lark, *Eremophila alpestris*; meadowlark, *Sturnella neglecta*; brown-shouldered lizard, *Uta stansburiana*; and sand cricket, *Stenopelmatus* sp.

PARASITES.—Kit foxes are commonly parasitized by the flea, *Pulex irritans*. After removing over 100 of these fleas from a male fox captured in January, 1955, it was estimated that twice that number remained on the host. Although most foxes had some fleas, occasionally one was captured that evidently supported no flea population.

Two kinds of ticks, *Dermacentor parumapertus* and *Ixodes texanus*, were collected from kit foxes from this area. The specimens of *Ixodes texanus* are the first to be collected from the kit fox in Utah. Unidentified roundworms and tapeworm proglottids were occasionally noted in the feces.

ENEMIES.—Soaring golden eagles, ferruginous rough-legged and red-tailed hawks were seen in the vicinity of kit fox dens, but none has been directly implicated as a fox predator in this area. The nocturnal horned owls also may be potential predators. Captive coyotes promptly killed and devoured a kit fox introduced into the same cage with them. However, this may have been a demonstration of territorial defense, as well as an act of predation.

Kit foxes are particularly vulnerable to cyanide guns and many are inadvertently destroyed during coyote control programs. Despite many published reports to the contrary, we have not found them to be particularly disturbed by man's presence, and kit foxes show little natural wariness of traps or poisons. Many are killed by vehicles on the highways in this region. Because of heat retention, paved roads are probably attractive to kit foxes; several have been noted sitting on the road at night. Many kit fox dens were known to have been uncovered by bull-dozer operators during road construction work in south-central Tooele County, Utah, 1951 through 1954. At dens, these foxes are easily approached within rifle and even shotgun range. Some are killed each year by rabbit hunters in this area.

OTHER ASSOCIATIONS.—One species of bird and several kinds of mammals and reptiles utilize abandoned fox dens. On several occasions burrowing owls were noted living in old dens. Antelope ground squirrels and brown-shouldered lizards also were seen entering empty dens. Many invertebrates, most of which are not identified, were collected while excavating a fox den. These will be reported later by specialists.

Present status.—According to O. W. Morris, District Agent for the U. S. Fish and Wildlife Service predator and rodent control program in Utah (letter, July 8, 1955), kit foxes have increased generally in western Utah since the introduction of modern predator control methods nine years ago. The practice of spacing "108 ' stations at wide intervals and of setting coyote-getter lines close to accessible roads has left large areas free of such devices, giving the shorter ranging kit fox large areas where it does not come in contact with coyote control activities.

Within the study area this fox has been common to abundant from 1951 to mid-1955. In the first half of 1955, 29 specimens were recorded in an area cover-

ing about 18 square miles. Of these, nine were adults; the remainder were pups of the year. This suggests an adult population of approximately five pairs for the area, or one pair per 3.6 square miles.

SUMMARY

The life history and distribution of the kit fox was studied from July, 1951, to July, 1955, in Tooele County, Utah. The principal aim was to determine the potential role of this species in the epizoology of endemic diseases in this area. Preliminary predator-prey and host-parasite relationships were determined but are admittedly incomplete. Once established, adult foxes probably maintain residence in an area for at least one year but may occupy several dens during that period. The kit fox is usually monogamous and breeding takes place probably in late December or early January. Pups are usually born in March or April. Families may remain together until the middle of September. About eighty per cent of the dens studied were located in shadscale flats of valley floors, where the vegetation consisted primarily of shadscale, grey molly and inkweed. Nine adults were recorded from an 18-square-mile area. This suggests an adult population of five pairs, or one pair per 3.6 square miles. Modern predator control methods, i.e., the widely spaced "1080" stations and the coyote-getter lines set close to accessible roads has left large areas free of such devices. A general increase in kit fox numbers in western Utah has resulted.

LITERATURE CITED

BARNES, C. T. 1927. Utah mammals, Bul. Univ. Utah, 17(12): 1–183.

DURRANT, S. D. 1952. Mammals of Utah, taxonomy and distribution. Univ. of Kansas, Mus. Nat. Hist. Pub. 6: 1–549.

FAUTIN, R. W. 1946. Biotic communities of the northern desert shrub biome in western Utah. Ecol. Monographs, 16: 351–310.

GRINNELL, J., J. DIXON, AND J. M. LINSDALE. 1937. Fur-bearing mammals of California. Univ. California Press, Vol. 2.

HALL, E. R. 1946. Mammals of Nevada. Univ. California Press. 710 p.

YOUNG, S. P., AND H. H. T. JACKSON. 1951. The clever coyote. The Stackpole Co., Harrisburg, Pa. 411 p.

Ecological Research, University of Utah. Dugway. Received December 11, 1955.

BEHAVIOR OF A POPULATION OF FOREST-MICE WHEN SUBJECTED TO POISON

By Lloyd Tevis, Jr.

A belt of Douglas-fir fronting the inland border of the north coast redwoods comprises the last great stand of virgin timber in California. Not previously exploited because of ruggedness of the mountains on which it grows, it is yielding now to the logging truck and caterpillar tractor. A timber rush is on. Within two or three decades little of the old forest will remain (Pine, 1953; Vaux, 1955).

As a rule, natural reproduction of conifers in the region is not sufficiently vigorous to replace timber removed by logging or destroyed by fire. Compared with the Douglas-fir belt of Oregon and Washington, environmental conditions in northern California are severe. The dry season is long and intense, and tan oak, which sprouts aggressively when felled or burned, often captures denuded land.

The answer to the problem of reforestation might be direct (artificial) seeding except for the presence of small mammals which are adept at finding and devouring coniferous seed. White-footed mice (*Peromyscus maniculatus* and *P. truei*), abroad only by night and inconspicuous out of proportion to their numbers, are the chief offenders. The diurnal and more obvious chipmunks (*Eutamias townsendii*) are of secondary importance, and shrews (*Sorex trowbridgii*) and red-backed mice (*Clethrionomys occidentalis*) are relatively scarce.

The recommended method of dealing with seed-eating rodents of the forest is to poison them (Eadie, 1954). In theory, foresters can wipe out a population of wild mice with lethal baits, then sow seed in the autumn and have a dense stand of seedlings after germination occurs in the following spring. But every attempt to protect seed by killing rodents with cereal baits in the California Douglas-fir region has failed.

Assuredly a rodenticide such as sodium fluoroacetate, commonly known as Compound 1080 (Kalmbach, 1945), is exceedingly effective when first applied. It can decimate a population of rodents; but Nature abhors a vacuum and invading mice soon stream into depopulated areas. Even buffer zones a quarter of a mile or more in width are traversed (Hooven, 1953). In the face of wave upon wave of invaders, invisible to man, control invariably collapses.

If we knew the reasons for the deterioration and final breakdown of control—why poison that is initially effective does not stop the reinvasion—then we might devise a successful technique for protecting coniferous seed in the California Douglas-fir region. Three reasons have been suggested to explain the failures of poisoning operations: 1) bait-shyness, 2) immunity to poison, and 3) destruction of toxicity and palatability of bait by rain. The last explanation is the one usually given for the Douglas-fir region, where winters are characterized by heavy precipitation.

Poisoned wheat in bait boxes.—An experiment was set up in Humboldt County to test the hypothesis that lasting control of forest-rodents might be achieved by protecting poisoned bait from weather. In early October of 1952, 45 wooden

bait boxes accessible to small mammals were distributed near Salyer over a fifteen-acre clearcut partly surrounded by virgin forest. They contained rolled wheat coated with Compound 1080 in a ratio of eight ounces of poison to 100 pounds of grain. This highly lethal bait, being protected from rain, was expected to kill invading rodents, as well as the resident population.

To determine the effectiveness of the technique, a line of 100 seed spots was planted with coniferous seed on various dates and examined daily. Before distribution of poison, the rate of seed spot robbery by rodents along this line was 100 per cent within three days. The animals found every seed. At that time, live-trapping revealed the presence of at least 31 mice, about two per acre.

The resident population succumbed abruptly to the poison. Rodent tracks did not reappear on the dusty logging road, and within a week the rate of seed spot robbery fell to zero.

In a nearby cutover that served as control for the test, storms coming in November destroyed the unprotected bait, whereupon invading mice quickly found most of the planted seed. But in the experimental area, where boxes shielded the bait from weather, the plantings were not disturbed by rodents. The poison was still effective.

Success thus marked the beginning of the experiment, but in late December, mice suddenly appeared and began to dig up seed even in the immediate vicinity of boxes, all of which contained dry poisoned bait. At first the rate of robbery was only 16 per cent in three days, but at each subsequent planting it went higher. By spring it was again 100 per cent. In a one-acre plot that had been planted during the fall, seedlings appeared on fewer than one out of every hundred spots. Once again rodents had nullified a direct seeding operation.

Live-traps set that spring on the poisoned area caught 13 mice, about one per acre. In spite of the bait, rodents were established on the cutover, and although fewer in number than the three or four per acre that were found on non-poisoned cutovers at that time, they were equally destructive.

The next step was to determine how they survived. On the assumption that the poisoned bait might have deteriorated, it was given to five caged mice captured *outside* the experimental area. These animals were provided also with plain foods; but they ate the poisoned bait and died within 24 hours. Hence, it was palatable and toxic.

Why, then, had it not killed the 13 mice occupying the cutover?

These individuals were put in cages to test their reactions to the bait. In contrast to the behavior of mice not caught on the experimental area, they refused to eat it. They ate other food. When that was replaced with untreated wheat, they starved. They would not touch poisoned *or* plain bait. They had acquired acute cases of bait-shyness.

Bait-shyness.—Bait-shyness is the reason why poisons on cereal baits cannot protect seed from forest rodents. It is a psychological phenomenon resulting when an animal takes a sublethal dose of poison and becomes conditioned by its painful experience.

No matter how strong a rodenticide may be, a few of the many individuals

that feed on it invariably are sickened before swallowing enough to kill themselves. Whereupon they stop eating. They associate their illness then with that particular bait and thereafter avoid it. As a consequence, a new population develops. It is composed of individuals who refuse poisoned grain but eat Douglas-fir seed.

Once a mouse has been sickened by poison, it is much more cautious than formerly about approaching new food. If given a different poison on a different bait, it usually becomes suspicious at the first trace of symptoms and stops eating instead of ingesting a lethal dose. Such individuals, who cannot be eliminated by any change of bait or poison, constitute a hard core of survivors of extermination campaigns against forest-mice. (They might succumb to an anti-coagulant, such as Warfarin, but field trials at Salyer with 0.025% Warfarin on wheat did not protect seed. The action of the poison was so slow that invading mice robbed innumerable seed spots before dying.)

The phenomenon of bait-shyness has been little studied in this country, yet it is well known to pest operators and is often mentioned by foresters in discussing the failure of efforts to protect seed from rodents (Schroeder, 1950). In England during World War II it was investigated in rats and house mice by the Bureau of Animal Population at Oxford. The Bureau found that the central difficulty in control by poisoning is that some individuals do not eat a lethal dose; after which the onset of illness makes them unwilling or unable to take more bait (Chitty, 1954).

The results of investigations at Oxford by Rzóska (1953, 1954) and Southern (1954), when compared with tests made at Salyer on caged *Peromyscus*, indicate that white-footed mice given a sublethal dose of poison behave like rats. As a general rule, a new bait, whether treated with the same or a different poison is accepted; but the same bait either treated with the same or a different poison or untreated is refused. In short, although the poison creates the illness, memory of it is associated with the bait. As previously stated, the thirteen white-footed mice at Salyer who had learned to avoid poisoned wheat also avoided plain wheat.

This fact suggested that the phenomenon of bait-shyness might be utilized to protect coniferous seed. If seed instead of cereal were used as bait, might not bait-shy mice avoid untreated seed? The intriguing possibility that a population of non seed-eating rodents could be developed on a cutover seemed worthy of investigation.

Poisoned Douglas-fir seed in bait boxes.—Of the various poisons that were commercially available to foresters when the experiment was started, Compound 1080 was the best qualified. An odoriferous and strongly-flavored rodenticide such as zinc phosphide was not desirable. It would provide an obvious opportunity for mice, who exhibit an acute sense of discrimination when confronted with toxic baits (Piper and Johnson, 1940), to distinguish between plain and poisoned seed. By contrast, Compound 1080 has no odor and only a slight taste (Anon., 1952). The fact that it is generally phytotoxic was not significant because the experiment was designed to determine if a small amount of poisoned seed, distributed at only a few sites, could protect an extensive planting of *untreated*

seed. In this respect it differed from tests reported by Spencer *et al.* (1954) in which all seeds were treated with tetramine (tetramethylene disulpho tetramine).

The area selected near Salyer was a new fifteen-acre clearcut surrounded on three sides by virgin forest and on the fourth by an old, shrubby cutover. The mouse population averaged about three individuals per acre. It was smaller in the forest and much larger in the brushland, the latter being a reservoir of potential invaders.

After a period of prebaiting, the initial kill was accomplished on August 3, 1953 by broadcasting poisoned wheat formulated with Compound 1080 according to the thoroughly tested specifications of the Oregon State Board of Forestry (Kallander and Berry, 1953; Lavender, 1952). This was done as an economy measure to reduce consumption of coniferous seed used as bait.

Then on the last day of the month a known number of Douglas-fir seed, previously soaked for 48 hours in a three per cent aqueous solution of Compound 1080, was deposited in each of 80 bait boxes. (Because Compound 1080 is soluble in water the seed had to be protected from weather.) The amount subsequently consumed by rodents was determined by making daily counts at each box and replacing losses. Plain seed, wheat, and walnut were included also for varying periods to test acceptance of untreated foods; but poisoned seed was maintained continuously in all boxes until late spring. From August 3 until the end of May, rodents on the area were subjected to poison.

The history and behavior of the mouse population was followed by use of a tracking technique. (Live-trapping was not employed because it disturbs the population and introduces artificial factors that can confuse and mask the effect of the poisoning.) A layer of flour deep enough to record tracks was dusted on the floor of each bait box. Then when an animal ventured within, it left a clear imprint of its visit as well as evidence of acceptance or rejection of poisoned bait and other foods. By erasing the tracks each day, the investigator could obtain a continuous record of rodent activity and of fluctuations in population numbers —the larger the population the more boxes visited during a twenty-four hour period. Unlike rats, which are suspicious of any new object in their environment (Shorten, 1954: 307), white-footed mice do not become "place-shy." Tracks of mice, chipmunks, and shrews were easily distinguished.

After a week of being prebaited with plain wheat, mice regularly visited most of the boxes, the actual number entered per twenty-four hour period ranging from 75 to 79 out of a possible 80. Under the impact of poison, the number crashed to four (Fig. 1).

During September and October, although the rate of visits remained low, there was hardly a time when a few boxes were not entered—irrefutable evidence that one or more mice were abroad on the cutover nearly every night. These individuals undoubtedly were invaders. Most of them died quickly from taking poisoned seed, but by the end of October at least one had survived and become a resident. This animal did not disturb seed spots or eat poisoned or plain seed or wheat. The only food in the boxes that interested the mouse was walnut, none of which had been treated with poison.

Such an individual is a valuable addition to the fauna of a cutover, for it

feeds on insect larvae, which may be injurious to coniferous seedlings (Jameson, 1952), and on weed and brush seed, which if not destroyed may grow into competitors of young trees.

Coinciding with severe storms sweeping in from the ocean, there was a spectacular increase during mid-November in the number of boxes visited by rodents. Apparently the rains that warned of approaching winter made the mice of surrounding areas restless, and a rising rate of invasion resulted in the establishment of a permanent population on the cutover. These animals regularly included the boxes in their foraging beats, and from then until the experiment was discontinued in May, a quarter to a half of the total number of boxes showed tracks

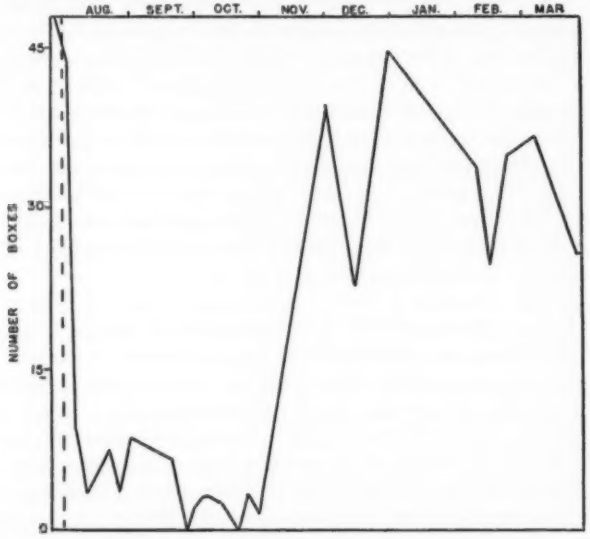


FIG. 1.—Number of boxes visited nightly by mice after distribution of poison (dashed line) on August 3. The average number of boxes entered per night before poisoning was 77.

every twenty-four hours, and nearly every box was entered at least once a week. Again and again all parts of the cutover were thoroughly explored by mice, the animals surviving because they had learned not to eat the poisoned seed that was in the boxes.

At that time stomach analyses showed that on a non-poisoned area, seed of Douglas-fir comprised half the daily diet of wild *Peromyscus*, but mice on the experimental area inspected plain seed in boxes without eating it and did not disturb old seed spots. Terminal live-trapping in May caught 14 individuals, all of which refused plain Douglas-fir seed. In short, natural selection had produced a temporary population of non seed-eaters.

These results demonstrated that poisoned seed distributed at a few sites can protect untreated seed from mice. But the simplified summary does not take into account various complicating factors that render the technique subject to

failure. Indeed, as Rzóska (1953) has pointed out: "Rodent control is often confronted with more complex kinds of behaviour than those usually analysed by animal psychologists."

Numbers of invading mice.—Because, usually, only new mice ate poisoned seed, the number of boxes at which such seed was taken during any twenty-four hour period approximated the number of new animals appearing in that time. On this basis, conservative calculations revealed that for the 261 days between September 1 and May 19, the fifteen-acre cutover was invaded by at least 730 mice, including those born on the area. Of these, 716 emigrated or were killed by poison and other lethal agents, for, as previously stated, terminal live-trapping

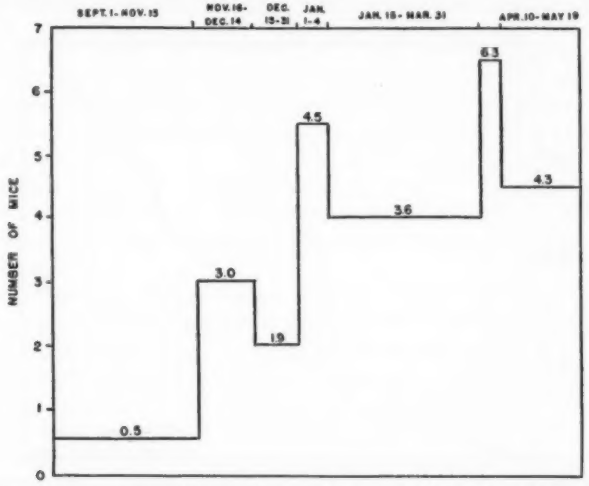


FIG. 2.—Average number of mice that invaded the poisoned area nightly. The graph is based on number of boxes in which poisoned Douglas-fir seed was eaten by mice.

caught only 14. (Some mice may have eaten poisoned seed in more than one box before dying or becoming bait-shy, but this possibility was counterbalanced by instances in which two or more invaders visited the same box in the same night.)

Although the average number of mice entering the cutover nightly for the entire period was between two and three, daily fluctuations were marked, and there was a progressive change in the average rate from fall to spring. The rate of invasion was lowest during the dry fall—less than one per night (Fig. 2). Thereafter there was a steady increase. By spring it was more than four per night, and the hazard to planted seed was greater than at any other time.

The explanation of the progressive change seemed to be that in the late summer and early fall, when breeding was at a minimum, the population was settled and there was little invasion of new areas. But at the beginning of winter rains, old mice began to move about in search of drier, communal homes; and renewed breeding, especially vigorous during late fall and early spring, soon released hordes of dispersing youngsters.

There were three invasion peaks: the lowest in November-December, a second in January, and the highest in April. The last two were correlated with preceding reproductive peaks.

A much larger number of invading mice originated in the brushfield than in the virgin forest. This was shown by the fact that poisoned seed was eaten three times more often in boxes adjoining the old cutover than in ones along the forest border. Hence, rodent control in a clearcut entirely within a virgin forest would be much easier than in one surrounded by brushfields. It would deal with fewer invaders.

Contrary to expectations, peripheral boxes located a few feet within the adjoining forest were not entered more frequently than centrally placed ones. Many

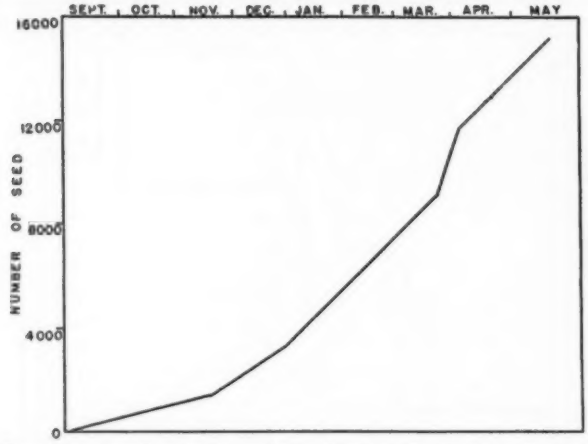


FIG. 3.—Cumulative number of poisoned Douglas-fir seed eaten by rodents, chiefly mice.

mice reached the heart of the cutover before being poisoned. Hence, bait stations should be distributed evenly on a grid pattern; a buffer strip within uncut forest is unnecessary.

Consumption of poisoned seed.—There was extraordinary variation in the amount of poisoned seed eaten by mice. Some caged individuals died after taking one or two seeds; others did not succumb until they had devoured at least twenty-five; and an occasional animal, who became bait-shy, was never killed.

The total number of poisoned seed that animals (mainly mice, although a few chipmunks were involved) consumed or took from the bait boxes between September 1 and May 19 was 15,206. Since Douglas-fir seed in California averages from 30,000 to 35,000 per pound, only about a half pound was consumed on the fifteen-acre cutover.

More seed was eaten in the spring than in the fall. The September amount was only 649, while for April it was 4,095, the cumulative total swinging sharply upwards after December (Fig. 3). Therefore, a delay in the start of control operations would not have saved a significant amount of bait. Even if poisoned seed

had not been distributed until December, approximately 13,000 would have been eaten.

Although the amount of seed consumed amounted to about one thousand per acre, a greater quantity was required to keep all boxes filled throughout the winter. The consumption was not evenly distributed, some boxes losing many more seeds than others. The average number of seeds eaten per box was 190, but the maximum was 755 and the minimum 6. Five (6%) of the eighty boxes lost more than 500 seeds; 10 (13%) more than 400; 13 (16%) more than 300; and 23 (29%) more than 200. Thus, under similar conditions, to insure that a significant number of bait boxes would not be emptied by rodents before spring, at least 300–400 poisoned seeds (24,000 to 32,000 per fifteen acres) should be deposited in each box. That amount is well within the limits of economic practicability.

More seed was taken from boxes at the edge of the brushfield (average 467) than in the remainder of the area (average 146). This fact leads to the conclusion that a cutover surrounded by brushfields will require much larger amounts of poisoned bait for maintenance of control than is necessary on a cutover in the heart of a virgin forest.

The smallest number of poisoned seeds, an average of 98 per box, was eaten under the forest edge. Hence, bait stations within the forest are the least effective. Better results can be obtained by placing all of them in the area where control is desired.

Resident population of mice.—Bait-shy mice, which constituted the resident population, avoided Douglas-fir seed yet regularly explored the boxes, leaving within tracks, droppings, and the remains of insects captured outside. Even when the boxes offered nothing but Douglas-fir seed, mice visited them frequently, as they did natural nooks and crannies, which, though lacking food during one night, might have a supply at another time.

The animals did most of their foraging on the cutover. They were loathe to penetrate the forest, where home sites and food were relatively scarce and the climate damp and cold. On the average, they visited boxes of the cutover three times more frequently than they did those located a few feet within the forest.

In October, when only one individual lived on the cutover, it was marked so that its tracks would be distinctive. Usually it entered three to five boxes each night and on succeeding nights ranged over different parts of the area, covering most of the cutover within four or five days.

When as many as 14 mice were present, which was the average estimated number from February to May, all of the cutover came under the keen scrutiny of *Peromyscus* nearly every night. At that time, probably, no one mouse included the entire area within its home range. Live-trapping studies by Hooven (1953) in the Tillamook Burn of Oregon indicated a range of about one-half acre per animal where the population was moderately dense. (Because traps usually catch rodents at points nearest their homes they do not always give reliable data on the maximum distances a mouse may travel during a night.)

Consumption of plain seed in boxes.—Resident mice, which accounted for 75 per cent of visits to boxes, normally ignored non-poisoned seed as completely as

they did seed that had been soaked in Compound 1080. Often they upset the small dish containing plain seed or pushed it about, but they would not eat the contents. Then in January there was a sudden increase—from 4 to 50 per cent—in the number of boxes in which *only* plain seed was eaten. The explanation was that at least one mouse had learned to distinguish between poisoned and non-poisoned seed. Thereafter, it entered boxes to feed on the plain seed—an undesirable development similar to a situation reported by Doty (1945) for wild rats in Hawaii. He found that even though the animals increasingly avoided poisoned oats they readily accepted plain cereal.

At Salyer there was a reason for the change in the reaction of the mice to plain bait. A few days previously the strength of the Compound 1080 solution had been increased from three to six per cent to reduce the number of poisoned seed required to kill or sicken invading animals. Thus the taste of the poison had been increased to a point at which at least one individual could detect it. This animal then refused the poisoned seeds but ate the plain ones.

In order to overcome this change in behavior before the mice attacked planted seed, the strength of the poison was lowered to one per cent. Whereupon the nightly disappearance of large amounts of plain seed from the boxes abruptly ceased. Apparently the offending mice, not then being able to discriminate between the treated and untreated bait, partook of the latter and were eliminated.

Although the six per cent application reduced seed consumption by about one-sixth, field tests made with seed soaked in 3, 1, and 0.25 per cent solutions showed no significant differences in the amounts at those levels consumed by invading mice. Therefore, in order to keep the taste of the poison at a minimum, the strength employed in control operations should not exceed one per cent.

Bait acceptance.—Because resident mice had been conditioned against eating wheat as well as Douglas-fir seed, acceptance of wheat and plain seed by the mouse population as a whole, both residents and invaders, was low. Out of the total number of recorded visits to boxes made by *Peromyscus* during the course of the experiment, poisoned seed was eaten 25 per cent of the time, plain seed 13 per cent (excluding the few days when 6 per cent 1080 was used), poisoned wheat 18 per cent, and plain wheat 19 per cent. By contrast, walnut meat, never having been treated with poison, was taken 90 per cent of the time.

The few visits when walnut was rejected are of some importance. They indicate that all mice do not react in the same way to all baits but that rare individuals are likely to refuse a food highly favored by the majority of a population. Certain caged mice, for example, never having been exposed to poison, would not eat Douglas-fir seed. This eccentricity of exceptional individuals complicates the problem of control.

When bait acceptance is judged in the field, allowance must be made for individuals who are not hungry. Satiation often increases idle exploring. No doubt some boxes were entered by animals who were not sufficiently hungry to feed on any food.

Robbery of seed spots.—The percentage of planted seed robbed by rodents is the final criterion by which success or failure of control techniques must be

judged. Little importance can be attached to the actual number of mice killed or conditioned against eating seed, for it takes only one individual seedeater to nullify the planting of a small cutover.

On non-poisoned cutovers at Salyer, the rate of seed spot robbery usually was 100 per cent *within a week*—a figure that served as a standard for comparison with poisoning results. On the poisoned area, five different plantings were made at 80 sites scattered over the entire cutting block. The sites were examined frequently, and numbers and dates of robberies recorded.

When the experiment was terminated in late May, the oldest planting, which dated from September 27, was the only one that had been highly successful. Only

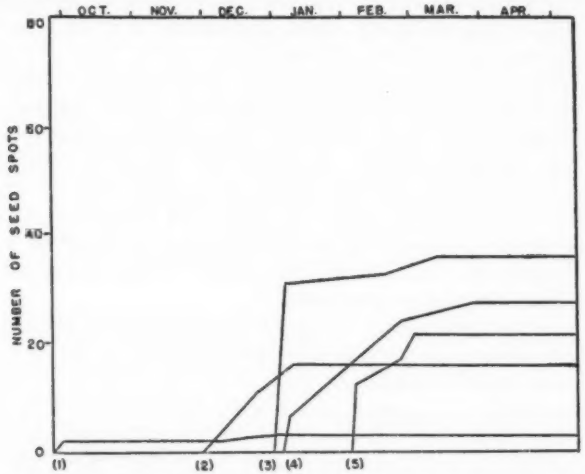


FIG. 4.—Cumulative numbers of seed spots robbed by mice on poisoned area. Each line represents a planting made at a different date. There were five plantings, as indicated by figures in parentheses. On non-poisoned areas all seed spots were robbed within a week.

4 per cent of its spots had been robbed; but a planting made on December 2 had lost 20 per cent; January 2: 46 per cent; January 12: 35 per cent; and February 9: 26 per cent.

This destruction was primarily the work of resident mice and not invaders, for although 34 per cent of the total spots on the cutover were disturbed, only four per cent were under the forest. As previously stated, resident mice foraged more frequently on the cutover than in the forest, while new invaders were likely to occur in either habitat.

Most of the robbery was done within the first month after seeds were in the ground (Fig. 4), the mice digging into the fresh plantings yet ignoring older ones that were only three or four inches away. The conclusion seemed obvious that seed buried for a number of weeks loses its attractiveness to rodents.

To test this possibility, 80 seed spots in a non-poisoned area were loaded with Douglas-fir seed and covered with wire screens to exclude rodents for three and

a half winter months. Then the screens were lifted. Promptly mice began to dig up the seeds, which they located by odor. Within three days they found all. Hence, the decline in rate of seed spot robbery on the poisoned area, after seed had been in the ground for awhile, had been an expression of the behavior of bait-shy individuals and was not characteristic of normal mice.

To explain the seemingly paradoxical fact that bait-shy animals ignore old plantings but attack new ones, the following hypothesis is suggested: The odor of seed that has been buried for a short or long time does not attract bait-shy mice, as it does normal individuals; but freshly disturbed and planted ground excites them. They dig in the loose soil. When they uncover a seed, either they discard it, or, if a considerable period of time has elapsed since a poisoning experience, they nibble on it cautiously. Then, finding that it is not injurious, once again they become wholehearted seed-eaters.

Rzóska (1954) noted that rats that have not been exposed to poison for some while will sample plain bait tentatively and cautiously. A lack of disturbing symptoms then further weakens their memory of the poisoning experience and finally obliterates bait-shyness altogether. Richter (1946) stated that bait-shyness in rats caused by Antu (alpha-naphthyl thiourea) is greatly reduced after sixteen days and practically absent by thirty. At Salyer, the presence of poisoned seed in the boxes apparently prevented a complete relapse of the condition, for animals whose bait-shyness was weakened by the passage of time had it reinforced as soon as they again sampled poisoned seed.

When mice with strong cases of bait-shyness dug into freshly planted soil, they scattered the seeds over the surface of the ground instead of eating them. Such seeds, then, were liable to be taken by birds.

Another peculiar but important aspect of the subject of seed spot robbery was that a close correlation existed between the rate of invasion, at the time a planting was made, and the subsequent rate of robbery. When animals were streaming into the cutover in large numbers, as during early January, more freshly-planted seeds were eaten by rodents than when only a few individuals were on the move, as in September. This might indicate that much of the damage was done by new mice who had not yet entered a bait box and partaken of poisoned seed.

In the main, though, the evidence showed that invaders ordinarily entered boxes without having dug up seed. This conclusion is based on hundreds of examples in which a mouse ate poisoned seeds in a box (hence, presumably the animal was an invader) but did not disturb plain seed that had been planted in the immediate vicinity of all boxes. The probable explanation of this behavior is that frequent visits to the boxes by the resident population of animals had created a network of trails, which, although invisible to the human eye, were followed by new mice on coming into the unfamiliar territory of the cutover. These trails led directly to the boxes.

The practical conclusion to be drawn from the observations that have been set forth in regard to seed spot robbery is that planting should be undertaken at a time when the mouse population is settled—in the fall—and should be com-

pleted not later than two weeks after distribution of poisoned bait. Then either there will be no mice present or only individuals who have recently become bait-shy.

SUMMARY

An experiment with the use of Douglas-fir seed as poisoned bait was conducted on a fifteen-acre cutover near Salyer in the California Douglas-fir region. In 261 days between September 1 and May 19, this area was invaded by at least 730 mice. In the fall, until the first big influx of new animals during mid-November, the rate of invasion averaged less than one per night, in the spring more than four. A total of 15,206 poisoned seeds was consumed by rodents. When seed was soaked in a six per cent aqueous solution of Compound 1080, some mice could distinguish between treated and plain seed, but not when a solution of one per cent or less was used. The most successful planting of untreated seed was made in September, when the rate of invasion by mice was low. Plantings made at later dates suffered varying amounts of robbery.

The study demonstrated that the phenomenon of bait-shyness can be used effectively to protect untreated seed from mice if proper procedures are employed. The object of the method is to develop a population of non seed-eating rodents rather than to try to eliminate all animals from an area where reforestation is desired.

Standard poisoning operations with grain bait kill only a part of the population. A few animals are sickened and survive. Thereafter these individuals avoid the bait and continue to destroy Douglas-fir seed. The new technique employs poisoned Douglas-fir seed instead of grain as the chief bait. The mice who eat this bait and survive are conditioned to avoid untreated seed. As a result, a non seed-eating population develops.

Many complicating factors created by the complex psychology, often eccentric behavior, and marked individual variation of wild mice render the method quite subject to failure. Among precautions that must be observed are the following:

1) Poisoned seed has to be present throughout the period when control is wanted. The amount required will depend upon the size and species-composition of the animal population and its capacity for reinvasion. Chipmunks and squirrels, if numerous, will remove more poisoned seed than mice. A cutover surrounded by brushfields will be invaded by a much greater number of animals than one within a virgin forest.

2) Seed used as poisoned bait must be protected from rain. Bait containers should be distributed evenly over a cutover; a buffer area is not needed.

3) The strength of the poison must be sufficient to prevent heavy consumption of poisoned seed but weak enough to keep rodents from distinguishing between treated and plain bait.

4) Planting should be accomplished when the rate of invasion by rodents is low and completed not later than two weeks after distribution of poisoned bait.

Acknowledgments.—This study was part of a co-operative investigation between the Department of Zoology of the University of California at Davis and

the California Forest and Range Experiment Station of the United States Forest Service. Valuable assistance was rendered by Douglass Roy of the Experiment Station, and Robley Broderick and Vern Hallin of the Six Rivers National Forest. Joseph Hinch of the office of the Humboldt County Agricultural Commissioner prepared some of the poisoned baits. Compound 1080 was donated by the California State Department of Agriculture, and lumber for bait boxes by the Holmes-Eureka Lumber Corporation. Dr. Tracy I. Storer read the manuscript and made helpful suggestions.

LITERATURE CITED

ANONYMOUS. 1952. Characteristics of common rodenticides. U.S. Fish & Wildlife Serv., Leaflet WL-337.

CHITTY, D. 1954. The study of the brown rat and its control by poison *in* "Control of rats and mice", Oxford, Clarendon Press, 1: 160–305.

DOTY, R. E. 1945. Rat control on Hawaiian sugar cane plantations. Hawaii Plant Rec., 49: 71–239.

EADIE, W. R. 1954. Animal control in field, farm, and forest. New York, MacMillan Co.

HOOVEN, E. F. 1953. Some experiments in baiting forest lands for the control of small seed eating mammals. Oregon State Board of Forestry, Research Bull. No. 8.

JAMESON, E. W., JR. 1952. Food of deer mice, *Peromyscus maniculatus* and *P. boylei*, in the northern Sierra Nevada, California. Jour. Mamm., 33: 50–60.

KALLANDER, R. M. AND D. BERRY. 1953. Aerial seeding, the methods and techniques employed by the Oregon State Board of Forestry. Oregon State Board of Forestry, Research Bull. No. 7.

KALMBACH, E. R. 1945. 1080, a war-produced rodenticide. Science, 102: 232–233.

LAVENDER, D. P. 1952. Field and laboratory tests of some forest rodent control preparations. Oregon State Board of Forestry, Research Notes, No. 6.

PINE, W. D. 1953. Humboldt's timber—a present and future problem. Humboldt County Board of Supervisors, Eureka, Calif.

PIPER, S. E. AND E. JOHNSON. 1940. Some studies of Peromyscus and other rodents in the San Bernardino Mountains of California 1937 to 1940. Bull. of State of Calif. Dept. of Agric., 29: 131–145.

RICHTER, C. P. 1946. Biological factors involved in poisoning rats with alpha-naphthyl thiourea (ANTU). Proc. Soc. Exper. Biol. and Medicine, 63: 364–372.

RZÓSKA, J. 1953. Bait-shyness, a study in rat behaviour. British Jour. Animal Behaviour, 1: 128–135.

———. 1954. The behaviour of white rats towards poison baits *in* Chitty and Southern "Control of rats and mice", Oxford, Clarendon Press, 2: 374–394.

SCHROEDER, G. H. 1950. Seeding of forest land from the air. Jour. Forestry, 48: 712–715.

SHORTEN, MONICA. 1954. The reaction of the brown rat towards changes in its environment *in* Chitty and Southern, "Control of rats and mice", Oxford, Clarendon Press, 2: 307–333.

SOUTHERN, H. N. 1954. The behaviour of the house mouse to poison bait *in* Chitty and Southern, "Control of rats and mice", Oxford, Clarendon Press, 3: 129–149.

SPENCER, D. A., N. B. KVERNO, E. W. SHAW, R. L. CASEBEER, AND W. H. HARMON. 1954. Symposium on rodent control research in the direct seeding of forest and range lands. Jour. Forestry, 52: 824–831.

VAUX, H. J. 1955. Timber in Humboldt County. Calif. Agric. Exper. Sta., Bull. 748.

Department of Zoology, University of California, Davis, California. *Received October 1, 1955.*

A FIVE-YEAR CHANGE IN AN ASSEMBLAGE OF WOOD RAT HOUSES

By Jean M. Linsdale and Lloyd Tevis, Jr.

The house of the dusky-footed wood rat (*Neotoma fuscipes*) in California is an impressive structure compared with the small size of the animal that makes it. The owner of a house assembles sticks, bark, plant cuttings, and miscellaneous objects that it deposits in a conical heap, which may tower six feet or higher above the ground and have a basal diameter of eight feet. Passageways penetrate the interior and one or more chambers contain a soft nest for the repose of the occupant.

Old and dominant individuals generally maintain and control several houses from which they exclude all other members of the colony. A mother and her young may occupy a house, but otherwise a single rat lives in a house. Long residence in the same house is rare. More often a rat shifts its headquarters frequently to a different dwelling within its sphere of influence. Occasionally, too, abandoning its own property, it may make a major move to a new area where it takes over a group of houses that belonged to an animal that died or moved elsewhere.

As a rule only established rats build new houses. When young rats leave the maternal abode, they must find unoccupied dwellings in which to live, for construction of new homes is time consuming, and homeless rats cannot survive long enough to make a new shelter. Increase of a population of rats, therefore, is dependent in part upon the frequency with which established animals build houses and the vigor with which they maintain old houses.

Most houses are occupied by a succession of tenants that persist in the upkeep of the structure, which then represents the work of many generations of rats. If a house is vacant for a considerable time, it loses its rat sign, such as deposits of feces and urine, and the trails that make a network about the house. Then it may be abandoned permanently. It then rapidly disintegrates and disappears because it is no longer maintained by frequent additions.

An assemblage of houses supporting a population of wood rats is never static. It is in continuous fluxion between constructive and destructive forces. Among the major influences that operate to eliminate houses are reductions in the rat population, unfavorable changes in the environment, and catastrophies to individual dwellings. Such catastrophies include washing away of a house by flood, crushing of it by a fallen tree, destruction of it by a predator, undermining of the base by ground squirrels, and collapse of overhead cover, leaving the house exposed to the heat of summer and the rains of winter, either of which may make it unlivable.

This paper records the results of an examination of an assemblage of marked houses at the Hastings Natural History Reservation in Monterey County, California. The examination was made after a five-year interval, and its purpose was to determine, if possible, how the rats and houses had fared during that time.

The houses are clustered in a riparian thicket on an area known as Long Field. This thicket is about half a mile long and averages 100 feet wide. It is composed

chiefly of oaks and tree-forming willows and such shrubs as rose and blackberry. These plants provide building material, support, cover, and screen. They are important elements in the construction and maintenance of houses. They also supply food.

The rat population of the thicket was originally studied by live-trapping at various times from 1938 to 1947 (Linsdale and Tevis, THE DUSKY-FOOTED WOOD RAT, 1951) but not during the period covered by this report. Some houses were marked in 1940 and 1942, and all of them in 1946. Then in 1947 and again in 1952, newly-built houses were marked, the presence or disappearance of old ones recorded, and each house was classified as "usable" or "not usable."

A house that is not usable is either an old one that has deteriorated beyond repair or a new one as yet too small to be occupied. Usable houses, on the other hand, are substantial structures that are generally in good condition. Their numbers represent the true size of the assemblage of houses.

Studies of the rat population made between 1940 and 1947 indicated that the population was essentially a stable one in that period. Yearly fluctuations in numbers of rats or their dwellings appeared to be slight. In March of 1947, of the 122 houses 95 were usable. Thirty-five rats were present at that time.

Significant and drastic changes occurred in the environment during the five-year period covered by this report, from March of 1947 to March of 1952. Many of the willows were killed or injured by drought and many of the blackberry and rose thickets were reduced by severe browsing by deer, which had become unusually numerous. The number of wildcats had increased. Then early in 1952 there was a flood.

It might be expected that these environmental changes would result in deleterious effects on the wood rat population. Instead, from 1947 to 1952 the number of usable houses increased from 95 to 139—a surprising gain of 44.

Further analysis of the records, as given in Tables 1, 2, and 3 provides some indications of how this increase came about, after a long period of apparent stability, and warrants the following conclusions:

The five-year interval was one of intense house building and maintenance by the rats. Out of 95 usable houses existing in 1947, only 9 (10%) were allowed to disappear and 8 (8%) to become unusable. In addition the rats restored almost one-half (48%) of the houses that had been in decay in 1947 and constructed an average of at least 11.6 new dwellings per year. The 139 usable houses present in 1952 consisted of 48 (34%) new ones, 13 (10%) rebuilt old ones, and 78 (56%) maintained old ones.

Some houses were quite old. Of the 139 usable dwellings present in 1952, three were known to be at least 13 years old, twelve at least 12 years, thirty-four at least 11 years, and nine at least 10 years old. Most of them were undoubtedly much older than the figures indicate, for when first marked they had been large structures.

Loss of support provided by blackberry and rose proved to be one of the most important causes for the decay or disappearance of houses. The continuous settling resulted in disintegration, abandonment, and ultimate disappearance of

TABLE 1.—*Status and age of 163 houses in 1952*

Status	New	Old
24 (15%) not usable	10 (42%)	14 (58%)
139 (85%) usable	48 (34%)	91 (66%)
163 Total	58 (35%)	105 (65%)

TABLE 2.—*Status in 1952 of the 122 houses present in 1947*

Status in 1947	1952		
	Disappeared	Not usable	Usable
95 (78%) usable	9 (10%)	8 (8%)	78 (82%)
27 (23%) not usable	8 (30%)	6 (22%)	13 (48%)
122 Total	17 (14%)	14 (12%)	91 (74%)

TABLE 3.—*Status in 1947 of the 105 houses present in 1952*

Status in 1952	1947	
	Not usable	Usable
91 usable	13 (14%)	78 (86%)
14 not usable	6 (43%)	8 (57%)
105 Total	19 (18%)	86 (82%)

the house even though the rats heaped large amounts of durable material on the structure. Because drought, severe browsing, and trampling by deer from 1947 to 1952 killed much of the rose and greatly reduced the tangles of blackberry, many houses that depended on these plants for support and cover deteriorated.

The optimum height for a house is about 40 inches. One that is too small does not provide adequate living space and protection for a rat, and one that is too large requires excessive amounts of maintenance. The size of the house depends partly on the kind of material used in its construction. Houses composed of fragile objects, such as mugwort (*Artemisia douglasiana*), are smaller than ones composed of durable material such as oak bark. Because rats usually select whatever material is most readily available in the immediate vicinity of a house, the kind used at any one site is surprisingly constant over the years. Houses made of non-durable objects often decay faster, at least during the winter, than new material can be added. Disintegration is most rapid under conditions of shade and dampness; but the opposite conditions of light and dryness are not favorable to the rats themselves.

New houses are likely to be started in the fall of the year. The initial deposition of building material often occurs where there is an obstacle, such as a fallen branch, which prompts a stick carrying animal to drop its load. Then, after a while, the leaving of sticks at that spot becomes a habit, and when a sizable pile results, passageways are cut into it. Hence, the stimulus for the building of new houses is the appearance of new sites.

Between 1947 and 1952 the killing of numerous huge willows by drought was the chief cause for the increase in number of houses. The dead limbs and trunks that fell to the ground yielded an abundance of building material. But, more important, they created new stimuli for the deposition of twigs by rats and provided support for subsequent erection of massive structures. When examined in 1952 most of the new houses were bulky, in good condition, and well maintained. A frequently utilized kind of support was the end of a dead willow trunk that had bent over until it touched the ground.

Since new houses are not built by homeless animals, the number of dwellings present is an effective limit to the size of the rodent population. New houses, representing the energy and enterprise of established individuals, must be constructed before additional numbers of animals can be incorporated into the group. In short, a colony of rats cannot expand faster than the supply of houses, or, vice versa, increase in houses must precede increase in rats.

The evidence indicates that in spite of seemingly adverse changes in the environment, rats did increase during the five-year period covered by this report. Apparently, many more rats lived in the thicket of Long Field in 1952 than in 1947. Drought and browsing by deer, although destructive to many plants, did not bring about a food shortage or seriously restrict the total amount of cover; greater predation by wildcats, if it occurred, had a negligible effect. The explanation for the increase in numbers of rats probably is to be found in the disintegration of the willows. The fallen branches and trunks stimulated house building by the resident animals. Then additional houses made it possible for the same area to support additional rats. Young individuals found suitable dwellings nearby instead of having to go elsewhere in their search for homes.

Hastings Natural History Reservation, Carmel Valley, California, and Department of Zoology, University of California, Davis. Received October 12, 1955.

INFRARED EMISSIVITIES OF SOME ARCTIC FAUNA

By H. T. Hammel

Heat loss by radiation from a warm surface to its cold environment depends not only upon the temperatures of the surface and the environment but also upon the emissivities of the surface and the environment, as expressed by the Stefan-Boltzman Law for total radiation

$$H_R = E_e E_r S_0 (T_r^4 - T_e^4) A$$

where H_R = radiant heat exchange from a radiator r to the environmental surfaces e, in gm cal./sec.

R_r and E_e = the emissivity of the radiator surface and the environmental surfaces respectively

T_r and T_e = the absolute temperature of the radiator and its environment

S_0 = Stefan-Boltzman constant = 1.37×10^{-12} gm cal./sec./cm.^{2}

A = the effective radiating area of the radiator

Kirchhoff's law states that the ratio of the radiating power (the emissivity) to the absorbing power is a constant for all surfaces at the same temperature, and therefore a surface that absorbs perfectly must radiate perfectly. All real surfaces radiate somewhat less than a perfect black body, the perfect radiator. Polished metal surfaces radiate very little whereas black painted surfaces radiate within a few per cent of the perfect black body. Hardy (1934) has shown that the emissivity of human skin is 100 per cent of the perfect black body. That the human skin radiates and absorbs like a black body regardless of its visible color is understandable in terms of the wave lengths involved in the coloration of the skin and radiation from the skin. Reference to Figure 1 shows that coloration of the skin is perceived by the eye in a narrow band of wave lengths extending from about 0.4 μ to 0.7 μ. It is in this narrow visible band that the greater part of solar radiation received at the earth's surface occurs. Radiation from the skin at 32°C, on the other hand, occurs in a wave length band extending from about 4 μ to 40 μ. It is clear therefore that the skin is black in the far infrared where it radiates energy but may range in color from dark to light in the visible part of the spectrum.

There is current the belief that an Arctic mammal or bird may derive some advantage from being white, because it will lose less heat by radiation due to its whiteness (Hamilton, 1939; Hesse, Allee, Schmidt, 1952). The error in this deduction lies in the fact that an animal that is white for visible wave lengths is not necessarily "white" in the far infrared at which it is radiating energy. There would, of course, be a sparing of heat if the emissivity of the surface of an animal were a small fraction of the black body radiator, since the radiant heat loss is proportional to the emissivity.

During January, 1955, the total emissivity in the infrared was measured for the surfaces of several Alaskan mammals and one bird. The method used was that described by Hardy (1934) to measure the emissivity of human skin. The

radiant energy exchange between a radiometer (Stoll, 1954) at room temperature (+20°C) and the fur or plumage surface at −20°C was compared with the energy exchange between the radiometer and a black body at the same temperature as the fur (−20°C). Since the emissivity of a black body is 1.00 over the entire infrared spectrum, the emissivity of the unknown was, therefore, simply the ratio of the radiometer deflection when directed toward the unknown to the deflection when directed toward the black body. The reliability of the method is limited by how closely the actual temperature of the unknown surface can be made to approximate the temperature of the black body. In this study the furs and the black body were placed in an unheated, well insulated room many hours

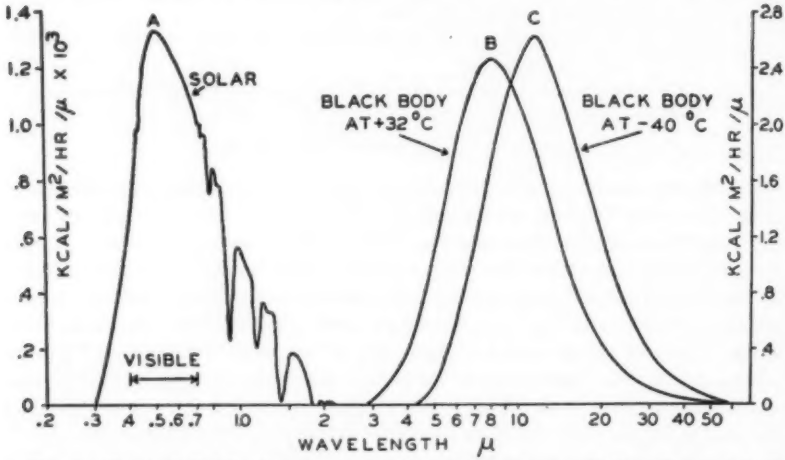


FIG. 1.—Spectral distribution of solar and low temperature radiation. Curve A is the solar radiation received at earth's surface with sun at zenith (air mass = 1) (Redrawn from Blum, 1945). Curve B is radiation from a black body at +32°C to surroundings at +22°C. Curve C is radiation from a black body at −40°C to surroundings at −80°C.

before the measurement of emissivity was made. The values of emissivity obtained in this way are probably reliable to within ±2 per cent.

For every fur and plumage surface studied, the emissivity was not measurably different from 1.00 as shown in Table 1. That is, in the far infrared all surfaces were black. The furs measured were tanned winter pelts of the pine marten, sea otter, beaver, red fox, gray wolf, lynx, bobcat and snowshoe hare and a fresh frozen winter pelt of the barren ground caribou. The emissivities of a freshly frozen snowshoe hare and a freshly frozen willow ptarmigan in white winter plumage were also measured and were 1.00 within the experimental error of the method.

Even though the emissivity of fur is 1.00, there will be little loss of radiant energy to those environmental surfaces that are at air temperature because the surface temperature of a well-furred mammal may be nearly the same as the temperature of the air (Hammel, 1955). However, Hardy and Stoll (1954) found

TABLE 1.—*Total infrared emissivities of some Arctic fauna*

Species	Visible surface color	Condition of pelage	Emissivity
Willow ptarmigan (*Lagopus lagopus*)	White	On frozen carcass	.98
Snowshoe hare (*Lepus americanus*)	White	On frozen carcass	.99
Barren ground caribou (*Rangifer arcticus*)	Whitish brown	Frozen; off carcass	1.00
Sea otter (*Enhydra lutris*)	Brownish black	Tanned	.98
Gray wolf (*Canis lupus*)	Light gray	Tanned	.99
Gray wolf (*Canis lupus*)	Dark gray	Tanned	.99
Beaver (*Castor canadensis*)	Dark brown	Tanned	.99
Beaver (*Castor canadensis*)	Dark brown	Dry	1.00
Lynx (*Lynx canadensis*)	Gray phase	Tanned	1.00
Red fox (*Vulpes fulva*)	Red phase	Tanned	.98
Red fox (*Vulpes fulva*)	Cross phase	Tanned	1.00
Marten (*Martes americana*)	Brown	Tanned	1.00
Bobcat (*Lynx rufus*)	Reddish brown	Tanned	1.00
Black body radiator			1.00

that when the sky is clear and the air temperature is below −40°C, the radiant temperature of the sky in the Arctic may be 30 to 40°C colder than the air temperature. Therefore, the upper half of an animal's environment when the sky is clear is an important radiant energy sink, since the emissivity of the animal's surface is nearly 1.00. Curve C of Figure 1 illustrates the magnitude of the radiant energy loss of a black body at −40°C radiating to a surface at −80°C. It seems likely that no Arctic fauna has adapted to its radiation environment by acquiring a surface of low emissivity in the far infrared. Habits have been adopted, however, which may serve the same end. The snowshoe hare may avoid exposure to the sky by taking cover beneath underbrush while it forages for food, or it may not forage at all when the radiant temperature of the sky is extremely low. The musk ox and the reindeer forage beneath a cloud of moisture exhaled by the herd. This thin cloud may be all that is necessary to shield their radiating surfaces from the sky.

Summary.—The total infrared emissivities of ten species of Arctic fauna were found to be like that of a perfect black body radiator.

Acknowledgments.—This research was supported by the United States Air Force through the Office of Scientific Research of the Air Research and Develop-

ment Command and the study was made at the Arctic Aeromedical Laboratory, Ladd Air Force Base, Alaska. The tanned furs were made available by Dr. John L. Buckley, University of Alaska. The technical assistance of Capt. Robert E. Hedblom was greatly appreciated.

LITERATURE CITED

BLUM, H. F. 1945. The physiological effects of sunlight on man. Physiol. Rev., 25: 483.
HAMILTON, W. J., JR. 1939. American mammals, Ed. 1. McGraw-Hill Book Co. p. 111.
HAMMEL, H. T. 1955. Thermal properties of fur. Am. Jour. Physiol., 182.
HARDY, J. D. 1934. The radiation of heat from the human body. III. The human skin as a black-body radiator. Jour. Clin. Invest., 19: 615.
HARDY, J. D. AND A. M. STOLL. 1954. Measurement of radiant heat load on man in summer and winter Alaskan climates. Jour. Appl. Physiol., 7: 200.
HESSE, R., W. C. ALLEE AND K. P. SCHMIDT. 1951. Ecological animal geography, Ed. 2. John Wiley and Sons. p. 616.
STOLL, A. M. 1954. A wide-range thermistor radiometer for the measurement of skin temperature and environmental radiant temperature. Rev. Sci. Instr., 25: 184.

Department of Physiology, School of Medicine, University of Pennsylvania, Philadelphia 4.
Received October 14, 1955.

THE RELATION OF COLORATION IN MAMMALS TO LOW TEMPERATURE

BY ARTHUR SVIHLA

It is well known that the color of certain mammals, such as the snowshoe hares (*Lepus*), collared lemmings (*Dicrostonyx*), weasels (*Mustela*) and Arctic foxes (*Alopex*) changes with the seasons, the animals becoming white in winter and brown in summer. The explanation usually advanced is that this seasonal difference in coloration renders the animals inconspicuous against the snows of winter and the brown background in summer and thus they avoid detection.

Recently another interpretation has been advanced to account for these coloration changes. The following quotation taken from Hesse, Allee and Schmidt's ECOLOGICAL ANIMAL GEOGRAPHY, Ed. 2, 1936, expresses the basic tenets of this concept. "The warm blooded animals of polar regions contrast . . . with . . . poikilothermic forms in their pale or pure white coloration. . . . The poikilothermic forms are almost all dark, and thus absorb the greatest amount of heat during the brief period of their activity. The white coloration of the homeotherms radiates less heat than the dark, and prevention of heat loss is evidently of greater importance than the absorption of the relatively small amounts of heat received from the sun. . . . Every means of heat conservation for homeothermic animals in polar regions is of importance, since they depend directly on heat of metabolism during the greater part of the year, and only secondarily on radiant heat from the sun."

In order to test the validity of the heat conservation concept the heat production of normally colored albino rats (*Rattus norvegicus*) was compared to those dyed black. Albino rats were used because of their uniform color and density of fur.

Preliminary experiments comparing weasels in the brown summer and white winter pelage showed that there were marked seasonal differences in fur density that could modify the results.

Acknowledgments.—Acknowledgment is made for aid and assistance to the Aeromedical Laboratory, Ladd Air Force Base, Fairbanks, Alaska, under contract 33(038)-18509. I am especially indebted to Dr. Loren D. Carlson of the Department of Physiology and Biophysics of the University of Washington School of Medicine for the use of equipment and facilities. I also express my sincere appreciation to Dr. Carlson and Walter Cottle for many helpful suggestions made during the study.

Techniques.—Adult rats of the Sprague-Dawley strain were used throughout the experiments. The dye used was commercial hair dye "Roux" Deep Black #101.

The data of the comparative production of heat by white and black rats were obtained (a) directly, from animals placed in an animal calorimeter; (b) indirectly, by computing the heat output of the same animals from the amount of oxygen consumed while in the calorimeter and (c) from the amount of food consumed while the animals were exposed at similar low temperatures.

Heat loss was measured with a constantly recording thermal-gradient animal calorimeter whose outer surface of the gradient layer was maintained at a constant temperature by the circulation of water through a jacket from a constant temperature water bath. Simultaneously the oxygen consumption was measured in a closed system with oxygen fed from a 1-liter spirometer. During each test the air supply was kept saturated.

Rats used in the food consumption experiments were kept in individual metal cages, and fed "Purina" ground chow. Water was available at all times. The animals were first kept in a warm room at 25 ± 2°C. for one week and then transferred to a cold room kept at 5 ± 1°C. for 21 days. Normal daylight and night conditions in the cold room were approximated by automatic regulation of the lights.

In the calorimeter each run lasted two hours, during which time heat loss from the animals and oxygen consumption were recorded continuously. The data presented are the mean rates of the final hour in the calorimeter.

Direct and Indirect Calorimetry.—In order to establish a base for comparison of heat production, undyed albino rats were first tested in the calorimeter at 24.5°C. Individual rats differed in the amount of heat that they liberated, the variations for 10 rats were from 1.05 to 1.70 K Cal/Hr with the mean being 1.26 K Cal/Hr. The mean heat production for the same rats as computed from their simultaneous oxygen consumption varied from 1.07 to 1.60 K Cal/Hr, the mean being 1.26 K Cal/Hr. Thus it is apparent that the figures for heat production obtained either directly (1.26 K Cal/Hr) or indirectly as computed from oxygen consumption (1.26 K Cal/Hr) were the same.

The rats were then exposed to temperatures of 5°C. There was an increase in heat production at this low temperature. The heat loss was found to vary from 2.53 to 3.51 K Cal/Hr with the mean being 2.86 K Cal/Hr as ascertained from

direct readings, and from 2.57 to 3.82 K Cal/Hr with a mean of 2.80 K Cal/Hr when calculated from their oxygen consumption. This is twice the heat output at 24.5°C.

After the rats had been dyed black they were again tested in the calorimeter at 5°C. and their heat output determined. As measured directly, the black rats liberated heat at the mean rate of 2.85 K Cal/Hr varying from 2.57 to 3.33 K Cal/Hr, or as computed indirectly from oxygen consumption varying from 2.18 to 3.52 K Cal/Hr with the mean being 2.81 K Cal/Hr.

Comparison.—If we compare these data, obtained directly from undyed rats (2.86 K Cal/Hr) with those obtained when they were dyed black (2.85 K Cal/Hr) or if we compare the data obtained simultaneously and computed indirectly from the oxygen consumptions, i.e., 2.80 K Cal/Hr for the undyed rats and 2.81 K Cal/Hr for the dyed rats, we find that the amount of heat liberated by both the undyed and the dyed rats is essentially the same (Table 1).

Indirect Calorimetry.—Food consumption may be taken as an indication of energy intake to compensate for increased caloric output resulting from exposure to low temperature.

Ten albino rats averaging 311.7 gm. during a period of seven days consumed on an average of 18.23 gm. of food a day at 24.5°C. During the same period of seven days, ten dyed rats averaging 312.6 gm. consumed on an average of 17.29 gm. of food a day at the same temperature. At 5°C. during a period of 21 days the same white rats consumed on an average of 29.69 gm. per day in order to compensate for heat lost at this lower temperature. During the same period the dyed rats at 5°C. consumed 29.42 gm. of food per day under the same conditions (Table 2).

The amounts of food consumed by both the white and the dyed rats were essentially the same, in fact the white rats consumed slightly more food than the black ones. The opposite should have occurred if white coloration is a better conserver of heat than black coloration.

TABLE 1.—*Heat loss of rats by direct and indirect methods*

Color	Direct, K Cal/Hr	Indirect, K Cal/Hr	Temperature
White	1.26 (1.05–1.70)	1.26 (1.07–1.60)	24.5°C.
White	2.86 (2.53–3.51)	2.80 (2.57–3.82)	5°C.
Black	2.85 (2.57–3.33)	2.81 (2.18–3.52)	5°C.

TABLE 2.—*Food consumption by rats*

Color	Average per day	Temperature	Number of days
White	18.23 grams	25°C.	7
Black	17.29 grams	25°C.	7
White	29.69 grams	5°C.	21
Black	29.42 grams	5°C.	21

Discussion.—Stullken and Heistand (Ecology, 34: 610–613, 1953) conducted experiments using dyed and undyed house mice and found that the dyed mice had a greater oxygen consumption than did the undyed mice at low temperatures. They concluded, therefore, that the white coloration was a more efficient heat conserver than the dark, supposedly by preventing heat radiation.

The results of our experiments, as indicated either by heat loss, oxygen consumption or food consumption do not confirm their results but on the other hand show that coloration had no effect on the conservation of heat or the prevention of heat radiation.

It is well known that only a small percentage of snowshoe hares and weasels in the southern part of their ranges and at low altitudes show seasonal dichromatism. The number of animals that do change increases progressively upward and to the north. Green (Jour. Mamm., 17: 247–249, 1936) has postulated a genetic explanation for this geographical difference in color change on a natural selection basis. Those individuals in the north or at high altitudes whose genetic makeup enabled them to change color survived as a result of natural selection whereas those that couldn't change color did not. In the southern part of the ranges and at low altitudes where there was greater variation in annual snowfall it might not be so necessary for all individuals to change color.

Very few experiments have been performed to test the effectiveness of natural selection on coloration, but the classical study of Davenport showed that white and other conspicuously colored chickens were selected first by predators leaving the inconspicuously colored ones. Sumner (Amer. Nat., 69: 245–266, 1935) showed the survival value of similarity of coloration of fishes to their background.

Our experiments show that insofar as heat conservation at low temperatures is concerned there is no difference between white and dark colored rats. Hence in this case, at least, the relation of white coloration to white background can best be explained on the basis of natural selection.

Department of Zoology, University of Washington, Seattle. *Received October 25, 1955.*

OSSIFICATION CENTERS AND SKELETAL DEVELOPMENT IN THE POSTNATAL VIRGINIA OPOSSUM

By Carlita L. Nesslinger

The opossum, *Didelphis marsupialis virginiana*, has been the subject of much study in regard to its anatomy, physiology, and ecology. The earliest accounts were morphological including descriptions of osteology by Tyson (1698) and Coues (1872). The extensive studies of Hartman (1923, 1928, 1952) cover breeding habits, development, and parturition as well as rate of development as determined by external characteristics. A detailed account of the embryology of the opossum by McCrady (1938) treats the development of various organ systems during the 12 to 13 day intrauterine period, but does not discuss the time of appearance of early bone centers in any detail.

In the absence of published reports on skeletal development, a study covering the period from birth to the time the young leave the pouch was suggested to the writer by Professor W. J. Hamilton, Jr., to whom thanks are due for critical reading of the manuscript. The research was supported in part by the New York State Science Service.

MATERIALS AND METHODS

The pouch-young opossums used in this study were obtained partly from the Cornell University Mammal Collection, from pouches of females killed on the highway, and by trapping pregnant females. A total of 234 specimens was prepared by the potash-alizarin method described by Dawson (1926) and Evans (1948). The length of time for clearing and staining and the strengths of the solutions varied with the size and general conditions of each specimen, but the general procedure was as follows.

Preparation and fixation.—Most specimens over two weeks old were eviscerated, especially if the gut was full. Larger individuals in which pigment and hair had appeared were skinned except for the feet and tail where removal of skin was difficult. Bleaching with hydrogen peroxide proved unsuccessful. Fat deposits were removed with the aid of forceps. Most of the specimens were fixed in ten per cent formalin for about one week and stored in 70 per cent alcohol. Those from the Cornell Collection that were stored in ten per cent formalin were softened in 95 per cent alcohol a few days before being cleared.

Initial clearing.—Potassium hydroxide solutions (made in distilled water) of two per cent and three per cent were used successfully on most specimens. Strong sunlight hastened clearing. Rapid maceration and softening of tissues were stopped by temporary return to 95 per cent alcohol.

Staining.—When long bones and tail vertebrae were visible through the opaque tissue, the specimen was ready for staining. Alizarin-red-S crystals were dissolved in two per cent KOH to make a saturated stock solution. The specimen was transferred to fresh potash solution and enough alizarin stain was added to produce a deep red wine color (usually 20 to 30 drops in an eight ounce jar). After 24 hours the specimen was usually sufficiently stained as indicated by color of

the bones and body tissue. Differential staining, in this case using toluidine blue for cartilage, was tried without success.

Destaining and final clearing.—Return to fresh KOH of the same strength used for clearing and staining removed excess stain in several days. Destaining solution was changed several times. Final clearing was accomplished by running up to pure glycerine in a graded series of glycerine and KOH. For small specimens one stage of one-to-one glycerine and KOH was sufficient. Larger specimens required three or four stages and did not attain the desired clarity for several months. Pure glycerine was used for storage and a pinch of thymol crystals was added to prevent mold growth.

CENTERS OF OSSIFICATION

The time of appearance and characteristics of the centers of ossification for the bones of the opossum skeleton are described here. A labelled diagram of the adult opossum skull is given in Figure 1. The subsequent figures illustrate the stages of development of selected bones of the skull and skeleton. Throughout the text, bones are referred to in the singular; it is understood, however, that in many cases they are paired.

Since only seven per cent of the specimens were of known age, the exact time of appearance in terms of days could not be determined. A critical study of the seven per cent, however, suggested that development might be divided into definite stages during which certain groups of bones first appeared. The period from birth to 85 days was thus divided into six stages. A key to these stages, representing distinct age groups, and used as the main point of reference, is presented in Table 1.

BONES OF THE SKULL

Dentary.—At birth, the bone of the lower jaw is more massive than any other and has a maximum length of five millimeters. It has a sharply defined upper and lower edge but the calcification is diffuse and weakly stained posteriorly. In two weeks the ramus has assumed a more definite shape in the form of the coronoid process, which extends up under the malar bone (Fig. 4, Bottom). At 28 days the condylar process has ossified and soon after that the angular process takes shape. Right and left moieties of the dentary have not quite come together at this time. Beginning with the fifth week the first teeth appear as brightly stained red tips. They are thus visible long before actual eruption. Mandibular teeth appear slightly earlier than maxillary teeth and the first three teeth to appear in both jaws are single tips of a canine, a premolar, and a molar. At six to seven weeks, eight incisors are present in the lower jaw, a canine and a premolar are represented by conical tips, the first molar exists as three to five separate cusps, and two or three minute cusps of a second molar appear suspended in the open trough of the jaw.

Premaxilla.—Right and left moieties of the premaxillary bone are separate and exist as delicate flat plates of bone at birth. Each premaxillary supports a long spinous projection directed posteriorly from the median edge and a shorter upturned spine from the dorsoexterior corner (Fig. 2, A). After a week, it is apparent that the former spine will contribute to the anteriormost area of the palate medial to the incisive foramina. The minute distal spine curves upward around the external naris.

Maxilla.—Three parts of the maxillary bones are present at birth. The palatine process is medial to the alveolar process (Fig. 2, A). Lying separately in the cheek region is the vertical frotnal process (Fig. 4, Top). During its early growth, the maxillary is fenestrated

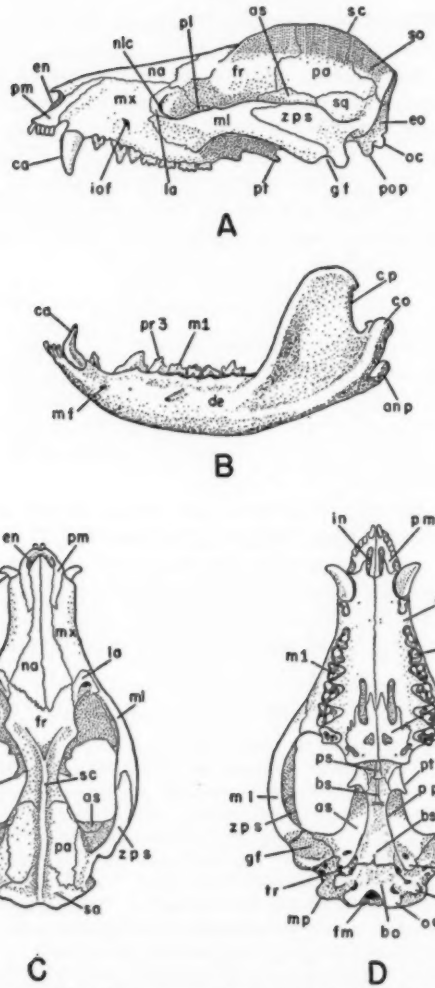


FIG. 1.—Osteology of the adult opossum skull. A. Lateral; B. Lateral view dentary; C. Dorsal; D. Ventral. AB = auditory bulla; ANP = angular process; APMX = alveolar process of maxillary; AS = alisphenoid; BO = basioccipital; BS = basisphenoid; CA = canine; CO = condyle; CP = coronoid process; DE = dentary; EN = external naris; EO = exoccipital; FM = foramen magnum; FR = frontal; GF = glenoid fossa; IN = internal naris or incisive foramen; IOF = infraorbital foramen; LA = lacrimal; M-1 = first molar tooth; MF = mandibular foramen; ML = malar; MP = mastoid process; MX = maxilla; NA = nasal; NLC = naso-lacrimal canal; OC = occipital condyle; PA = parietal; PL = palatine; PM = premaxilla; POP = paroccipital process of exoccipital; PPB = pterygoid process of basisphenoid; PR-3 = third premolar tooth; PS = presphenoid; PT = pterygoid; SC = sagittal crest; SO = supraoccipital; SQ = squamosal; TR = tympanic ring; ZPS = zygomatic process of squamosal.

TABLE 1.—*Key to the identification of stages of ossification in opossum pouch-young*

A. Teeth absent, or not more than 6 cusps per jaw.
1. Manus and pes totally unossified or at most a few early bone centers present.
a. No visible ossification in diaphysis of femur, tibia, and fibula.....Stage I
b. Femur, tibia, and fibula centers of ossification 0.5 to 2 mm. long.....Stage II
2. Some bony centers of digits present. No carpals or tarsals.
a. All primary ossification centers of digits of manus present; few or none in pes. No teeth.....Stage III
b. All primary ossification centers of digits of manus and pes present. Dental formula:

$$I\ \frac{0}{0}\ C\ \frac{1}{1}\ PM\ \frac{1}{1}\ M\ \frac{1}{1}$$

.....Stage IV

B. Incisors, canines, premolars, molars represented. Carpals and tarsals present.
1. Teeth not exceeding:

$$I\ \frac{5}{4}\ C\ \frac{1}{1}\ PM\ \frac{1}{1}\ M\ \frac{2}{2}$$

1 to 6 carpals; 1 to 3 tarsals.....Stage V
2. Dental formula:

$$I\ \frac{5}{4}\ C\ \frac{1}{1}\ PM\ \frac{2}{2}\ M\ \frac{2}{2\text{-}3}$$

7 to 8 carpals; 4 to 7 tarsals.....Stage VI

to give an almost net-like appearance, particularly in the frontal region. At four weeks, the maxilla has increased in size so that it is overlapped by the premaxilla anteriorly, fuses with the nasal for a short distance, overlaps part of the lacrimal, and fuses with the malar ventroposteriorly. The infraorbital foramen is proportionately large. During the fifth and sixth weeks minute incisors appear in the premaxillary; the tips of a canine, a premolar and a molar appear much as in the dentary (Fig. 5, Bottom).

Lacrimal.—A minute two-pronged piece of bone lying free near the orbit at birth, the lacrimal soon extends partly under the maxillary and over the frontal (Fig. 4). At four weeks the nasolacrimal canal is the largest of several fenestra in this small bone.

Nasal.—At birth, the nasal is a small saddle of bone when viewed laterally (Fig. 4, Top). The halves are separate and do not fuse medially until about eight weeks. Their fusion with the frontal and maxillary is complete after four weeks (Fig. 3, D).

Frontal.—A very pale staining area of incipient ossification above the orbit is the incipient frontal (Fig. 4, Top). During the first postnatal week, bone growth is rapid, and at three weeks a thickened area of bone forms the superciliary ridge (Fig. 5, Top) and the precranial constriction is apparent (Fig. 3, D).

Parietal.—Ossified tissue is not present (i.e., staining does not occur) in the roof of the skull at birth. A trace appears during the first week and the growth of bony spicules radiates outward from a true bony center of parietal ossification during the next week. The advancement of the frontal and parietal bones toward the midline of the calvarium can be measured by the decrease in size of the fronto-parietal fontanelle (Fig. 3, C, D). After the fourth week this small gap quickly closes over. At 85 days when observations were concluded, the smooth roof of the skull bore no evidence of the characteristic occipital crest whose increased height indicates advanced age in adult skulls.

Interparietal.—Appearing at the end of the first week, this thin band of bone has a solid posterior edge from which delicate calcified spicules are deposited anteriorly. Continued forward growth appears as a jagged edge advancing toward the fronto-parietal fontanelle (Fig. 3, C).

Supraoccipital.—In the second postnatal week a thin transverse strip of bone appears behind the interparietal (Fig. 3, B). At three weeks the unpaired supraoccipital is overlapped by the interparietal, and at four weeks fusion between the two bones is effected

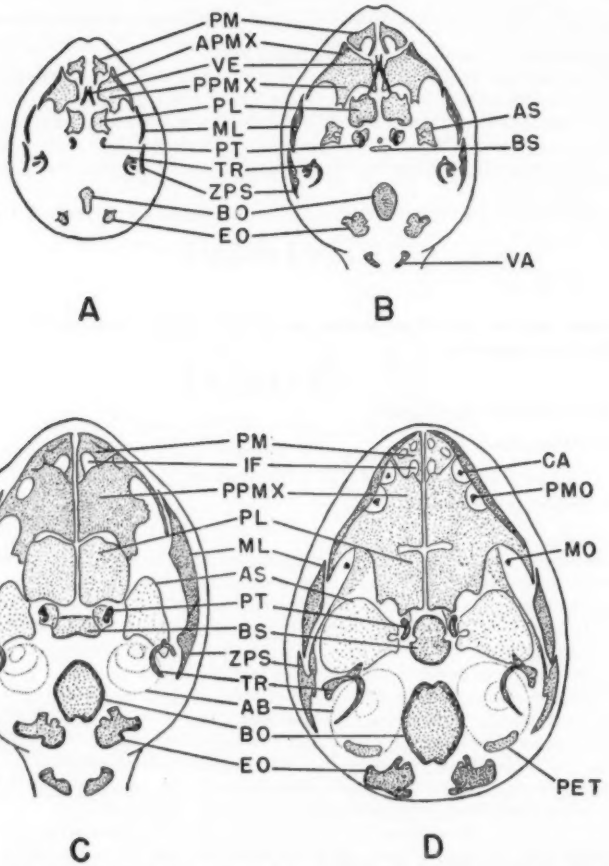


FIG. 2.—Diagrams of base of the skull seen in ventral view during each of the first four stages of ossification. A. Stage I, about 3 days; B. Stage II, about 8 days; C. Stage III, about 16 days; D. Stage IV, about 28 days. IF = incisive foramen; MO = molar tooth; PET = petromastoid; PMO = premolar; PPMX = palatine process of maxillary; VA = vertebral arch of atlas; VE = vomer-ethmoid. (For other abbreviations see Fig. 1.)

leaving no evidence of a suture. Thus Coues (1872), in describing the osteology fails to mention an interparietal, referring to this bone of double origin as the supraoccipital.

Exoccipital.—Present at birth are two widely separated moieties of the exoccipital, located so far back that they may be mistaken for the atlas vertebra (Fig. 4, Top). Each has an irregular shape and at four weeks, has a thick truncate knob anteriorly, a shorter knob medially, and a thick faceted area indicating its future union with the basioccipital. A lateral knob is the early paroccipital process. At eight weeks the bone is still isolated.

Basioccipital.—A minute wedge-shaped trace of bone lying between the exoccipitals in the ventral midline is the basioccipital (Fig. 2, A). Present a few days after birth, it ossifies heavily, particularly around the edges (Fig. 2, C). Complete fusion with surrounding bones does not take place during the pouch stage.

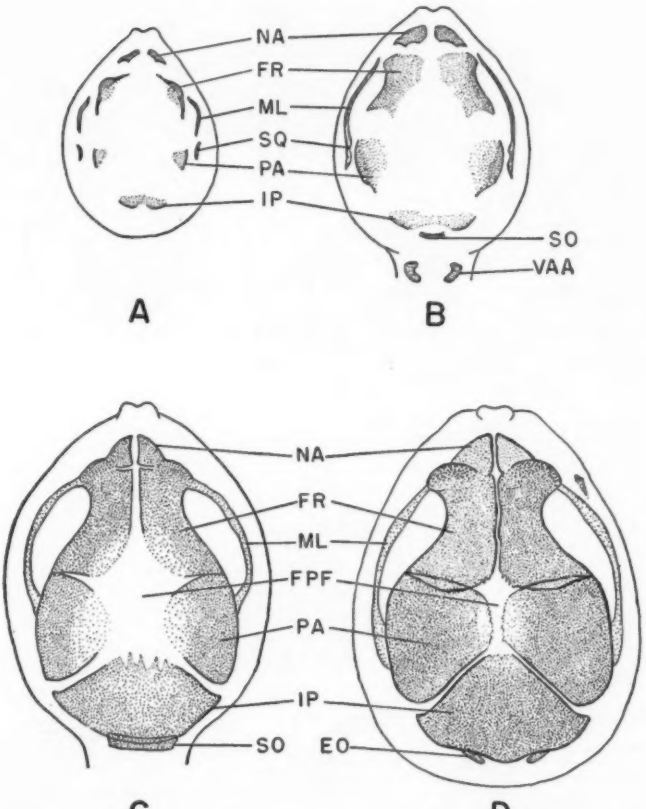


FIG. 3.—Diagrams of dorsal view of the skull during each of the first four stages of ossification. A. Stage I, about 3 days; B. Stage II, about 8 days; C. Stage III, about 16 days; D. Stage IV, about 28 days. FPF = fronto-parietal fontanelle; IP = interparietal; VAA = vertebral arch of atlas. (For other abbreviations see Fig. 1.)

Basisphenoid.—Appearing during the second week as a thin bar of bone medial to the pterygoids, the basisphenoid grows rapidly and assumes a distinctive shape (Fig. 2, D). After the fifth week it becomes contiguous with the pterygoids.

Presphenoid.—Soon after the formation of the basisphenoid, a small dot of bone appears anterior to it (Fig. 2, B). The presphenoid is considered to be part of the vomer complex since it becomes incorporated in the vomer-ethmoid after the fourth week.

Orbitosphenoid.—After the fourth week the orbitosphenoid occupies the area from the frontal above to the maxillary shelf below. At seven weeks it forms part of the orbito-temporal fossa wall.

Alisphenoid.—Contributing even more bone to the wall of the orbito-temporal fossa is the fan shaped alisphenoid. During the second week, it arises as two centers of ossification that fuse almost immediately to enclose a conspicuous foramen (Fig. 2, B). With continued growth the bone extends up to the orbital region, back to the bulla, and down to the ptery-

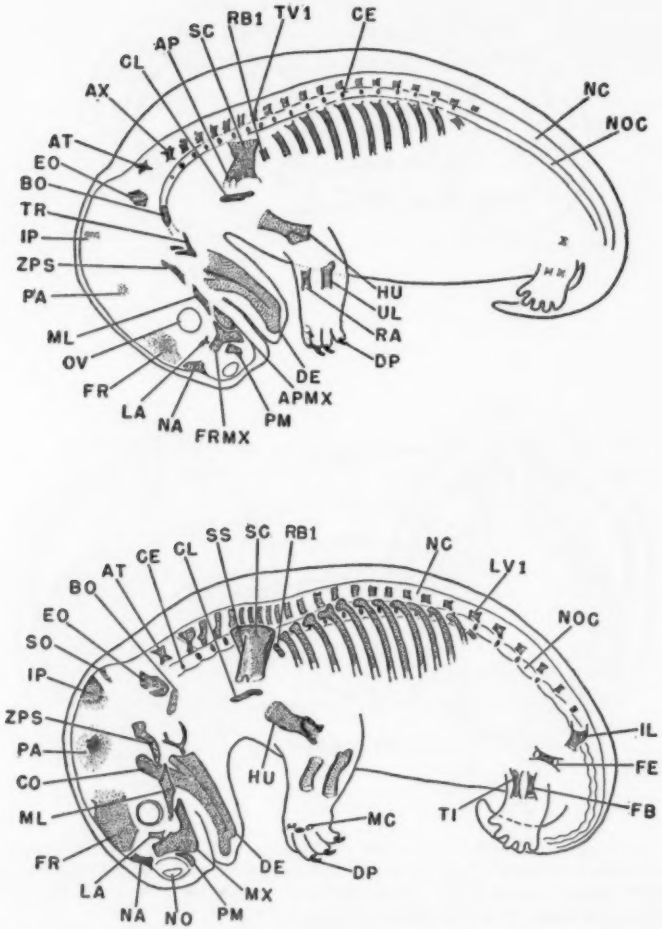


FIG. 4.—Skeletons of postnatal opossums. TOP: Fifth day, 15 mm.; BOTTOM: Second week, 20 mm. AP = acromion process; AT = atlas; AX = axis; CE = centrum; CL = clavicle; CO = coronoid process; DP = distal phalanx; FB = fibula; FE = femur; FRMX = frontal process of maxillary; HU = humerus; IL = ilium; IP = interparietal; LA = lacrimal; LV-1 = first lumbar vertebra; MC = metacarpal; MX = maxilla; NC = nerve cord; NO = narial opening; NOC = notochord; OV = optic vesicle; RA = radius; RB-1 = first rib; SC = scapula; SS = scapular spine; TI = tibia; TV-1 = first thoracic vertebra; UL = ulna. (For other abbreviations see Fig. 1.)

goids and basisphenoid. The original foramen is occluded and during downward growth the foramen ovale is formed (Fig. 2, D).

Vomer.—A few days after birth a small A-shaped bone lying in the nasal cavity is the first evidence of the vomer (Fig. 2, A). At four weeks it is elongated and a dorsally project-

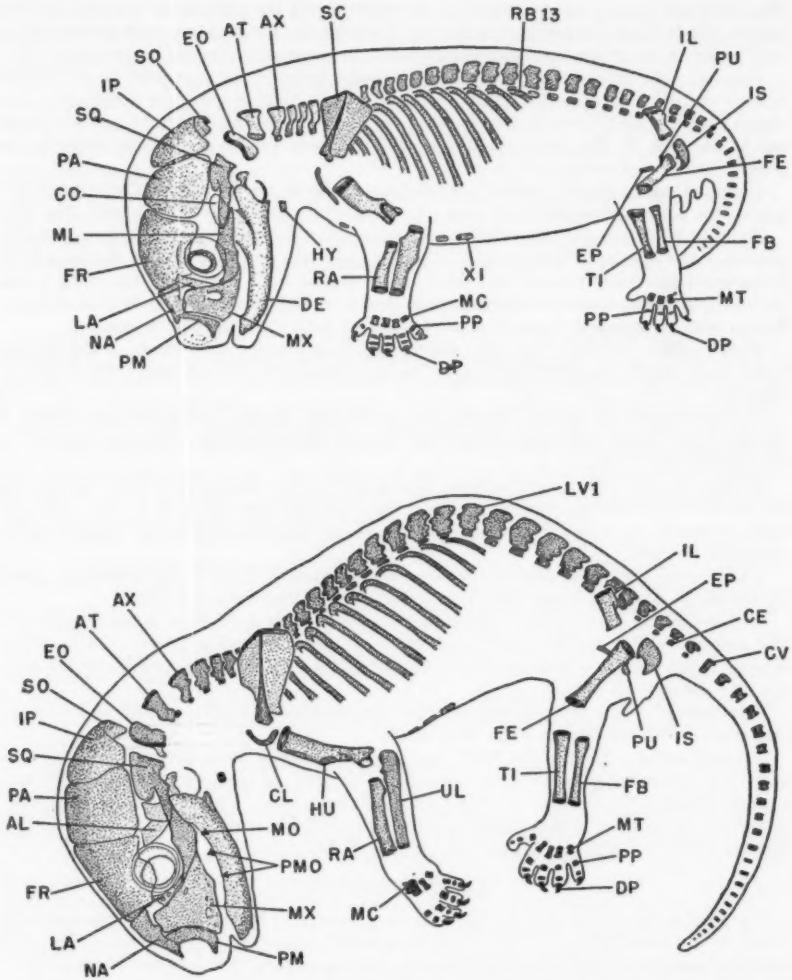


FIG. 5.—Opossum skeletons. TOP: Stage III, 30 mm. BOTTOM: Stage IV, 45 mm. AL = alisphenoid; CE = centrum; CV = caudal vertebra; EP = epipubic bone; HY = thyrohyal; IS = ischium; MO = molar; MT = metatarsal; PMO = premolar; PP = proximal phalanx; PU = pubic bone; RB-13 = thirteenth rib; UL = ulna; XI = xiphoid process. (For other abbreviations see Figs. 1 and 4.)

ing ridge from each side of the paired structure will become the nasal septum. The anterior projections unite with part of the premaxillary at this time.

Ethmoid.—The more complex ethmoid bone, appearing during the second week, includes a central thick mass of porous bone from which lateral wings grow outward. After four weeks

the cribriform plate is recognizable. By the seventh week the ossification of the turbinates begins with isolated bony centers in the maxilloturbinals. Three or four rods are the initial ossification of the ethmoturbinals and dorsally the nasoturbinal scroll begins to ossify.

Palatine.—At birth a small well formed palatine bone center is present on either side behind the palato-maxillary. After continued growth they occupy the posterior palate region, fusing with the maxillaries at three weeks but remaining separated medially until much later (Fig. 2). The characteristic palatine foramina are not identifiable owing to the general fenestrated nature of this bone.

Pterygoid.—Immediately behind the palatines, at birth, are the minute C-shaped pterygoids. It is a heavily ossified bone with a flat base which abuts the basisphenoid (Fig. 2).

Squamosal.—A slender bony center appearing a few days after birth is the zygomatic process of the squamosal (Fig. 4, Top). Located above the posterior edge of the lower jaw, it elongates anteriorly toward the malar. In the second week a posterior flattening is the beginning of the squamous temporal portion, and a ventral notch is the early glenoid fossa. Fusion with surrounding bones does not take place until after the eighth week.

Malar.—Directly below the optic vesicle, ossifying shortly after birth, is the slender malar bone center. It grows back under the squamosal and forward above the maxillary (Fig. 4).

Tympanic ring.—At birth a conspicuous ossification present at the posterior angle of the dentary is the anterior part of the ring. Shaped like a wishbone, it is soon covered by the dentary (Fig. 2, 4).

Malleus process.—This short tapered bone is present on the day after birth. It lies free surrounded by the slender curved prongs of the tympanic bone (Figs. 2, 4). Not until the sixth or seventh week does the malleus begin to ossify, followed later by the fusion with its spine-like process.

Auditory ossicles.—The three ear bones ossify after the sixth week, each arising in place. By the eighth week the incus comes in contact with the malleus and stapes.

Auditory bulla.—In the fifth week ossification begins at several places in the spiral bulla. The posterior wall has a wide bony band, and two inner coils each have a curved fragment of bone. Small patches of bone appear on the anterior wall of the bulla. Ossification is complete by the seventh week.

Petromastoid.—The petrosal and mastoid are apparently closely related and arise in conjunction with the osseous bulla (Fig. 2, D).

Visceral arches.—During the third week, a pair of small rods directed medially and anteriorly appears at the base of the tongue (Fig. 5, Top). At the apex of these thyrohyals, a small, round basihyal begins to ossify after six weeks. Next, a pair of small, round ceratohyals forms anterior to the thyrohyals. By eight weeks, a pair of calcified rods near the trachea probably represents the arytenoids (Fig. 7, A).

AXIAL SKELETON

Vertebral arches.—The moieties of the atlas, present at birth, are well separated and dorsal to the exoccipital. Present below the vertebra is a minute hypocentrum. The axis centers of ossification are longer than the atlas, and succeeding vertebral arches are smaller. The last vertebral arch is above the twelfth rib. A centrum, corresponding to each vertebra, is present in the region of the notochord. In the second week the arches are higher and assume more definite shape. A few lumbar arches appear, the last one is usually present before its centrum ossifies. In the next week sacral and the anteriormost caudal vertebral arch centers ossify. At four weeks most caudal vertebrae are present (Fig. 5, Bottom). All but the first few have a single ossification center which later develops a neural crest. Near the eighth week right and left halves of the arches have nearly come together dorsally, and centra fill the gaps between them ventrally. In another week, chevron bones ossify ventral to the caudal centra. They start as paired elements for the first five or six caudal vertebrae and as single centers in the rest of the tail. At this time the axis has the flaring neural crest which projects over the atlas. The odontoid process lies below the atlas with the hypocentrum ventral to that.

Ribs.—At birth twelve ribs are present, the first and last being very short, the sixth the longest. The periosteal bone gives the appearance of a flaring ostium dorsally. The cartilage anlagen of the entire future rib can be seen in well cleared preparations. In the second week the dorsal ends are ossified to form a capitulum but they do not articulate with the vertebral column as yet. At 14 days the thirteenth rib makes its appearance (Fig. 4, Bottom). During the eighth week a thin waving line of calcification appears within the sternal rib cartilage linking the ossified thoracic ribs to the sternum. There are 11 sternal cartilages, nine of which show ossification (Fig. 7, B).

Sternum.—During the third and fourth weeks the six sternal elements begin to ossify more or less simultaneously. There is some variation in order of appearance: either the manubrium and xiphisternum appear first, or anterior sternebrae are first. Occasionally sternebrae (usually the fourth or fifth) have a double origin of two small bone centers.

APPENDICULAR SKELETON

Pectoral girdle.—The scapula is a stout bony cylinder at birth, appearing truncate at both ends and having a faucet-shaped acromion process anteriorly. In the second week a scapular ridge is present; it rapidly increases in height. Near the fourth week, the typical fan shape of the scapula is evident, its edges are better ossified and the acromion process flares at its extremity. The scapular spine or ridge may be so thin that a foramen is present in the bone (Fig. 6, B). The coracoid appears during the seventh week close to the proximal end of the scapula (Fig. 6, A). The clavicle is present at birth as an oblique slender rod directed medially, posteriorly, and downward. Small at first, it elongates and nearly contacts the sternum, humerus, and scapula at the sixth week (Fig. 4, 5).

Pelvic girdle.—At birth, hind limb, pelvic, and caudal elements are conspicuously absent. The ilium ossification center, appearing in the second week, is a stocky bone broadest at its proximal end (Fig. 4, Bottom). The ischium is a small claw-shaped bone appearing a week later ventral to the ilium (Fig. 5, Top). The pubic bone appears in the fourth week as a small rod anterior to the ischium. At the same time the slender, paired epipubic bones arise anterior to the pubes. All pelvic elements are well separated until after the eighth week when pubis and ischium are fused ventrally and ilium, ischium, and pubis nearly meet at the acetabular region (Fig. 6, C). Only a thin separation exists at the pubic symphysis. The epipubic bones elongate and have an expanded base which will eventually hinge against the anterior face of a pubic bone.

Hindlimb.—Femur, tibia, and fibula begin to ossify at the same time and maintain a similar size and shape during their first four weeks. At about seven days, the diaphysis of each is one millimeter long and at 14 days, two millimeters. These cylinders of periosteal bone grow in length and width. At 60 days the head of the femur is recognizable and within a few days the greater and lesser trochanter are formed. Two condyles are present at the distal end of the femur. Below each condyle is an epiphysis, the posterior one appearing at about 55 days, the anterior at 75 days. The tibia has a proximal epiphysis, and both tibia and fibula have a distal epiphysis at 70 days. Tibia and fibula are not fused at this stage but matching facets are present on each both proximally and distally.

Forelimb.—In the newborn, the long bones of the forelimb are well defined cylinders of periosteal bone. The humerus is a stout shaft widest at the distal end where there is a notch at the site of the future ectepicondyle. At the third week the diaphysis is about four millimeters long and has a deltoid crest and expanded ect- and entepicondyles (Fig. 5, Top). An entepicondylar foramen is present at 35 days. Soon after that two proximal and one distal humeral epiphysis appear. The radius and ulna are about one millimeter long at birth, but at three weeks the diaphysis of the ulna is the longer and has an olecranon process and a notch for humeral articulation. At about 75 days a distal ulnar epiphysis ossifies, followed by a distal radial epiphysis, and later, a proximal ulnar epiphysis. All epiphyses of the long bones lie within the cartilage that caps the ends of these bones.

Carpals.—The bones of the carpus appear in a definite sequence which can be traced in a series of specimens. The cuneiform ossifies at about 37 days, followed by the scaphoid at 38 days. At 40 days the unciform is a dot of bone after which the trapezium and trapezoid

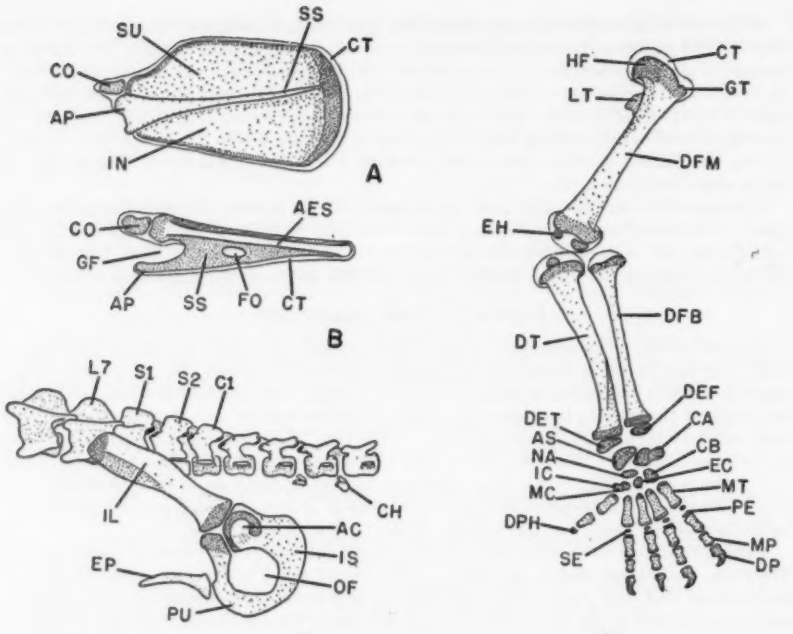


FIG. 6.—Condition at approximately 85 days. A. Pectoral girdle; B. End view of same; C. Pelvic girdle; D. Hindlimb slightly disarticulated. AC = acetabulum; AES = anterior edge scapula; AP = acromion process; AS = astragalus; C-1 = first caudal vertebra; CA = calcaneum; CB = cuboid; CH = chevron bone; CO = coracoid; CT = cartilage; DEF = distal epiphysis fibula; DET = distal epiphysis tibia; DFB = diaphysis fibula; DFM = diaphysis femur; DP = distal phalanx; DPH = distal phalanx hallux; DT = diaphysis tibia; EC = external cuneiform; EH = epiphysis of condyle; EP = epipubic bone; FO = foramen; GF = glenoid fossa; GT = greater trochanter; HF = head femur; IC = internal cuneiform; IL = ilium; IN = infraspinous fossa; IS = ischium; L-7 = seventh lumbar vertebra; LT = lesser trochanter; MC = middle cuneiform; MP = middle phalanx; MT = metatarsal; NA = navicular; OF = obturator foramen; PE = phalangeal epiphysis; PP = proximal phalanx; PU = pubis; S-1 = first sacral vertebra; S-2 = second sacral vertebra; SE = sesamoid bone; SS = scapular spine; SU = supraspinous fossa.

appear in close succession. At 75 days the pisiform and magnum are present. The arrangement is illustrated (Fig. 7, C). The centralia and two sesamoids reported in the adult have not appeared by the eighty-fifth day.

Tarsals.—The calcaneum ossifies first at about 35 days. By the fiftieth day a small astragalus bone center is present. The cuboid and external cuneiform are present on the sixtieth day, followed in order by the middle cuneiform, navicular, and internal cuneiform. A sesamoid eighth tarsal member (the prehallux) was not ossified during the scope of this study.

Metacarpals.—In the second postnatal week the three middle digits of the manus show early metacarpal ossification (Fig. 4, Bottom). They start as incomplete, delicate rings of bone and soon become thin wafers. First and fifth metacarpals appear in the third week. Subsequent growth in length occurs. These bones are slightly constricted in the middle and

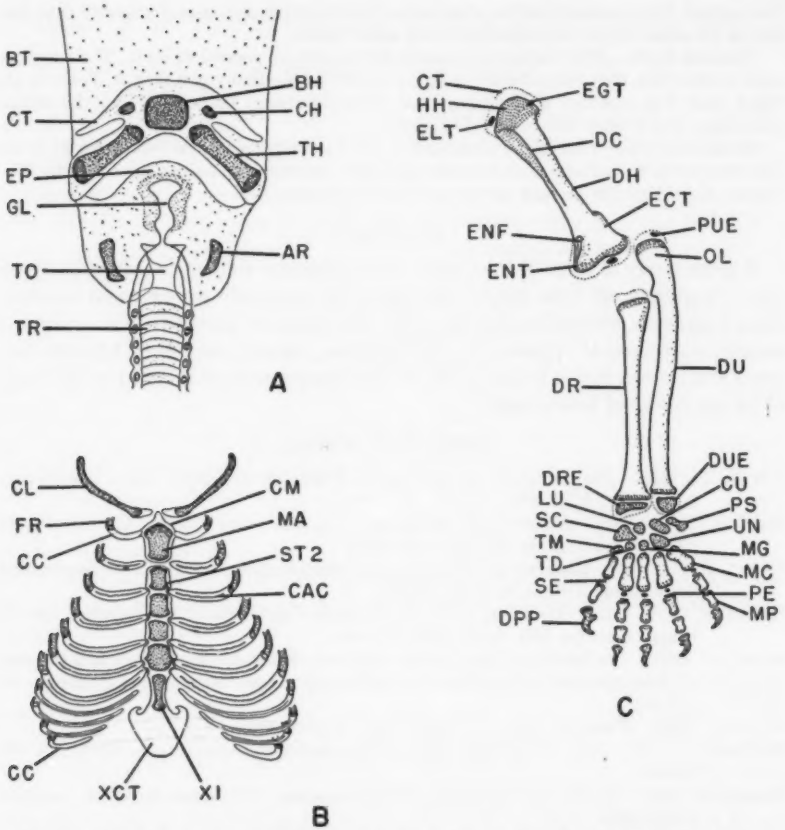


FIG. 7.—Condition at approximately 85 days. A. Visceral arches; B. Sternum; C. Forelimb slightly disarticulated. AR = arytenoid cartilage; BH = basihyal; BT = base of tongue; CAC = calcification in costal cartilage; CC = costal cartilage; CH = ceratohyal; CL = clavicle; CM = cartilage investment of manubrium; CT = cartilage; CU = cuneiform (ulnare); DC = deltoid crest; DH = diaphysis humerus; DPP = distal phalanx pollex; DR = diaphysis radius; DRE = distal radial epiphysis; DU = diaphysis ulna; DUE = distal ulnar epiphysis; ECT = ectepicondyle; EGT = epiphysis greater trochanter; ELT = epiphysis lesser trochanter; ENF = entepicondylar foramen; ENT = entepicondyle; EP = epiglottis; FR = cut end first rib; GL = glottis; HH = head of humerus; LU = lunare; MA = manubrium; MC = metacarpal; MG = magnum; MP = middle phalanx; OL = olecranon; PE = phalangeal epiphysis; PS = pisiform; PUE = proximal ulnar epiphysis; SC = scaphoid; SE = sesamoid bone; ST-2 = second sternebra; TD = trapezoid; TH = thyrohyal; TM = trapezium; TO = tracheal opening; TR = tracheal ring; UN = unciform; XCT = xiphoid cartilage; XI = xiphoid process.

heavily ossified at the ends. A sesamoid bone, distal to each metacarpal, ossifies after about seven weeks.

Metatarsals.—In the third week three central metatarsals appear in the pes (Fig. 5, Top). They also start as thin rings, soon becoming lamellar. At four weeks metatarsals one and

five appear. The opposable hallux often lacks the metatarso-phalangeal sesamoid that ossifies in the other digits after approximately eight weeks.

Forelimb digits.—Five distal phalanges in the manus are present at birth. Their appearance is claw-like, they stain deeply and project beyond the fleshy pad (Fig. 4, Top). In the third week five proximal phalanges appear, followed almost immediately by the middle phalanges. The former have a distal epiphysis.

Hindlimb digits.—Four distal phalanges in the pes ossify during the fourth week. In the following week the proximal and middle phalanges appear. The hallux has only two phalanges. Epiphyses are present on the proximal phalanges.

SUMMARY

A gross study of bone development in the opossum was made using 234 specimens ranging in age from birth to 85 days. The specimens were cleared in potassium hydroxide, stained in alizarin red-S, and stored in glycerine. The order and approximate time of appearance of ossification centers was noted. Growth patterns and time of fusion is described. Six age classes were established on the basis of 34 specimens of known age.

LITERATURE CITED

Coues, E. 1872. The osteology and myology of *Didelphys virginiana*. Mem. Boston Soc. Nat. Hist., 2: 41–149.

Dawson, A. B. 1926. A note on the staining of the skeleton of cleared specimens with alizarin red S. Stain Tech., 1: 123–124.

Evans, H. E. 1948. Clearing and staining small vertebrates, in toto, for demonstrating ossification. Turtox News, 26: 42–47.

Hartman, C. G. 1923. Breeding habits, development and birth of the opossum. Smithsonian rept. for 1921. Publ. 2689: 347–363.

———. 1928. The breeding season of the opossum (*Didelphis virginiana*) and the rate of intra-uterine and postnatal development. Jour. Morph. and Physiol., 46: 142–215.

———. 1952. Possums. Univ. of Texas Press. Austin. 174 p.

McCrady, E., Jr. 1938. The embryology of the opossum. Amer. Anat. Mem. No. 16. 233 p.

Tyson, E. 1698. Carigueya, seu Marsupiale Americanum. Phil. Trans. Roy. Soc. London, 4: 248–267.

Department of Conservation, Cornell University, Ithaca, N. Y. *Received December 12, 1955.*

MAMMALS OF THE THOUSAND ISLANDS REGION, NEW YORK

By William E. Werner, Jr.

In the headwaters of the St. Lawrence River as it flows from Lake Ontario along the New York State and Ontario border there is an archipelago of about 1700 islands. These islands range in size from a few tenths of an acre to several thousand acres, and are situated at varying distances from each other across the river, which in places is nearly seven miles wide. Since this area was inundated by sea water after the last glacier, the islands are considered to be no more than 10,000 years old.

At the suggestion of Dr. W. J. Hamilton, Jr., a study of the mammals of this region was conducted from December, 1952, to June, 1954. The purpose of the investigation was to extend the knowledge of the distribution of the mammals of this area, and to investigate the effects of the isolation and limited area of the islands upon the mammalian populations. Data secured from a study of the fauña on islands in this region might show how the size of populations, species composition, reproductive patterns and other population characteristics are related to the size and isolation of islands. By study of the distribution and habits of different species on islands of varying areas and distances from the mainland, the factors most probably limiting their distribution may be discovered.

Dr. Wm. J. Hamilton, Jr., of Cornell University advised me throughout the study. I am also indebted to Dr. J. N. Layne, Dr. J. Clovis, and Dr. C. R. Robins for identification of materials.

A search of the literature failed to reveal any specific study of mammals in this area. Several studies on other islands of a similar nature are to be found. River island studies include one by Pruitt (1951), who studied Sugar Island in St. Marys River, Michigan. He noted that some mammals are able to cross this river using the island as a bridge, while others are apparently stopped from their expansion by the river. The distance of this island, on which he found 23 species of mammals, from the mainland is not given, but from maps appears to be about 700 feet or less.

Lake island studies are more numerous. In one by Adams (1909) of Isle Royale, a list of mammals is given. Jackson (1920) studied the mammals on the Apostle Islands in Lake Superior and noted the effects of winter activity on their distribution. Hatt *et al.* (1948) studied the islands of Lake Michigan, noting all terrestrial vertebrates, and giving some theories to explain their distribution. Crissey and Darrow (1949) reported the mammals present on Valcour Island in Lake Champlain in their study of predation on that island. Hatt (1928) reported on the mammals of Sloop Island, adjacent to Valcour Island. A rather complete report of the mammals of the islands of Great Salt Lake was given by Marshall (1940). These islands were of special interest because of the extensive speciation that is supposed to have occurred there. Manville published three papers (1950*a*, 1950*b*, 1951) concerning mammals on small islands in Lake Huron, in which population structure and methods of study were the main subject of interest.

Of indirect importance to this study is the literature concerning rivers as

PLATE I

Aerial photograph of some of the study islands in the vicinity of Alexandria Bay, N. Y. The American mainland, including Alexandria Bay, is seen in the lower right hand side of the picture, with Wellesley Island (6) on the other side of the American channel of the St. Lawrence River in the upper left hand side of the photograph. Other islands shown include Welcome (1), Florence (2), Belle (3), Harbor (4), and Kipp (5).

barriers to dispersal, and the effects of island characteristics on populations. The effect of size of water gaps on distribution of animals is discussed by Darlington (1938), while Palmer (1937) gives evidence showing the effectiveness of a river as a barrier to the dispersal of certain species of moles. The effect of small size of islands is the topic of papers by Blair (1946) and Hinton (1931).

In this study, 1412 mammals were collected, measured, and weighed. Reproductive organs were examined before preservation. Food analysis studies were made later in the laboratory, in an effort to learn more of the habits of various species.

An attempt was made to remove all mammals from some of the smaller islands in order to determine rates of repopulation of such islands. Each island was trapped intensively, and then retrapped one or more times. The mainland was also studied in order to gain some impression of the species common in the area, and to have specimens for comparison with island forms. Most collecting was conducted during summer months, although one fall trip and several spring trips were also made.

Ten islands were selected for study, ranging in size from 0.8 acre to over 7,000 acres, with most of them being 1 to 18 acres. They extended about 10 miles along the river, within the limits of 44°16′ to 44°24′ north latitude and 76°04′ to 75°48′ west longitude. All islands studied were within the limits of Jefferson County, New York State.

The vegetation on the mainland is a beech-maple-hemlock climax; in some areas of extensive rock outcrop, the woodland type is oak-hickory. Much of the land is under cultivation, while some is abandoned farmland. Summer residences are abundant along the river. In some areas along the mainland there are marshy areas. Collecting was conducted along the shorelines of the mainland, and also one-half mile farther back along a cliff, apparently an old shoreline, in a northern hardwood forest. Here undergrowth was dense, and the ground covered with ferns and other herbs. Another area in which collecting was done was also a northern hardwood forest, and contained several woodland ponds and marshy areas, as well as extensive cliff and rock outcrop areas.

Belle Island, 1.07 acres in extent, is only 300 feet from Wellesley Island. It is at least partly artificially created. Half the island is the rubble of a former residence. Cover consisted mainly of grasses, white sweet clover and a few trees, mostly elms, around its periphery. A tangle of grape vines surrounds the house remains on one side. There was a sizable *Microtus* population on the island. Two small colonies (5 individuals) of *Blarina* were apparently exterminated in trapping during 1953. One *Condylura* was also taken there that year.

Douglas Island lies 150 feet from the nearest small island, and 3,500 feet from Wellesley Island. It is 8.5 acres in area. There is one marshy shore, but otherwise its shoreline is rocky. Northern hardwood forest covers about half the island, while a savanna of white pine and poverty grass and moss covers the remainder that is not rock outcrop. *Microtus* was abundant in the savanna area, with few in the woods, although old runways were common there. No *Blarina* were taken on the island in 1953, while two were captured in 1954 in the *Microtus* runways in the savanna area.

Florence Island is a small island of 1.22 acres. It lies 300 feet from Wellesley Island and only 200 feet from Belle Island. There is a rocky hill on which only larger trees and a few blueberry bushes and herbs grow. White pine, hemlock, and oak are the dominant trees which form the sparse vegetation. A patch of sorrel

and clover grows near the center of the island. The shoreline is rocky with a perpendicular cliff 15 to 20 feet high on one side. *Microtus* was the only mammal present. Three specimens of this species were trapped in the summer of 1953. Two weeks of additional trapping did not reveal further mice, but in October, 1953, a mouse was observed there, and in June, 1954, two colonies were established.

Harbor Island is a 17.2 acre wooded island, 700 feet from Kipp Island and 900 feet from Wellesley. Its shoreline is entirely rocky. The northern hardwood forest is largely open, with very little underbrush. Old runways were extensive in the thick duff on the forest floor. Most of the mammals were concentrated on a rocky, grassy slope on the northern end of the island, or in small clearings overgrown with raspberry bushes. *Microtus* was the most abundant mammal, although 18 *Condylura* and several *Blarina* were also taken there, usually in the raspberry thickets. All three of these species were found in the same locations, although *Microtus* was more universally distributed. The skeleton of a raccoon was also found on the island.

Ironsides Island was one of the most isolated islands studied, being 1900 feet from the mainland. This 18.8 acre wooded island has very rocky shorelines, with one side rising in a perpendicular cliff 40 feet above the water. The forest is northern hardwood, although white and red pine are present. There are extensive thickets of yew throughout the island, and two temporary ponds. The duff is thick, but rock outcrop is common. There are a few small grassy areas on one end of the island, but otherwise succulent herbs are scarce. Despite this lack of herbs, *Microtus* were very abundant throughout the island. No other mammals were found there.

Iroquois Island is a salient of the mainland that was made into an island by the construction of a canal. It is now separated by about 300 feet of water from the mainland and is approximately 14.3 acres in extent. There are two deserted houses, a boathouse and an icehouse on the island. A large part of the island is covered by a thick underbrush of honey-suckle under pine trees, while the remainder is covered with northern hardwood forest or rock outcrop. The shoreline is partly rocky, partly marshy, and there is a small, gentle, sandy beach in a protected cove. *Blarina* and *Peromyscus* populations were abnormally high on the southern part of this island in 1953, compared to all other places trapped. In 1954, the *Blarina* population was low, while *Peromyscus* remained abundant. Chipmunks were also common, both in 1953 and 1954. Bats (*Myotis lucifugus*) were collected in the boathouse on the southern part of the island. A single *Sorex fumeus* was collected here in 1953.

Kipp Island barely protrudes out of the water, and is often washed over with waves. It is only 0.8 acres in area, and lies about 1050 feet from Wellesley Island. It is covered with a dense thicket of alders and viburnums. The wetter areas are covered with grass and emergent aquatic plants. July, 1953, trapping reduced the population of *Microtus* drastically, yet retrapping in August showed that a fairly high population had been re-established. *Condylura* was present in 1953, but there was no sign of this mole in 1954.

Welcome Island is the site of a former yacht club the ruins of which form about

half of this 1.8 acre island. It lies about 500 feet from Wellesley Island, and has a rocky shoreline except for a cement sidewalk and dock on one side. Trees are planted around the periphery of the island only. The part of the island not rubble is artificially built up with a clay silt, and is covered with grass and sweet clover. In 1953, sparse grass and sumac offered some cover and food for mammals, but in 1954, the sweet clover had made a dense thicket and was inhabited by *Microtus*. This species was found distributed throughout the island. Only two specimens of *Blarina* were taken in 1953, and none the following year.

Wellesley Island is the largest of the islands studied, and one of the largest in the archipelago, being 7,940 acres in area. It is situated approximately 700 feet from the American mainland. Because of its size, it has all types of shorelines, from rocky to marshy and sandy. Also, its ecological diversity is nearly as great as is that of the mainland, although there are only one or two temporary ponds and streams. There are two villages on the island, and a main road to Canada passes over a bridge connecting the island to the mainland. Collecting was done mainly in three areas: a northern hardwood forest, a meadow, and a grassy bog. The northern hardwood forest adjoined an oak-hickory forest with many dead, hollow trees. The grassy bog was surrounded by a northern hardwood forest and a meadow, while the meadow most frequently trapped was situated on an inlet of the river. Nineteen species of mammals were taken or observed on this island.

Whiskey Island is the most isolated island studied, and one of the smaller, being only 0.8 acres. It lies 2,100 feet from the nearest island, and about 6,200 feet from the mainland. Its shores are entirely rocky, and it is covered with poverty grass and shrubs, mostly sumac and huckleberry. Only two *Microtus* were taken in 1953, but in 1954, two colonies of this species were found on the island. A hole with a trail leading to it indicated the presence of rats in 1953, but there was no sign of this species in 1954.

ACCOUNTS OF SPECIES

Condylura cristata Linnaeus. Star-nosed mole.—This species was found on the islands more easily accessible from the mainland or from Wellesley Island, where soil conditions were suitable. It was found on the smallest island (Kipp) where the land was very wet, but not on Florence Island, which is closer to Wellesley Island, and is composed of hard soil and rocks. Harbor Island is the most distant from other land areas on which this species was found.

On Kipp Island *Condylura* occurred in saturated soil. On Harbor Island, where the animal was quite abundant, specimens were most frequently taken in the leaf mold of the woods and in raspberry thickets in small clearings. Goldenrod thickets and moist meadows also yielded this mole. On several occasions *Microtus* and *Blarina* were trapped in *Condylura* tunnels.

Sorex fumeus fumeus Miller. Smoky shrew.—This species was found only on Wellesley Island and Iroquois Island, in addition to the mainland. The former is a large island, while the latter, although small, was once part of the mainland and is not far from it in a fairly undisturbed region.

The smoky shrew was the most abundant mammal in a talus slope in a northern hardwood forest on the mainland. This locality was cool and moist, being a north slope. However, in the summer of 1953 specimens were collected around a grassy bog and in the center

of a meadow several hundred feet from the nearest woods on Wellesley Island. Trapping in these same localities in 1954 did not produce any specimens, although they were still abundant on the mainland. In general, northern talus slopes produced most of the specimens.

Blarina brevicauda brevicauda Say. Short-tailed shrew.—Individuals with the last half of their tails white occurred on the mainland (1 specimen), on Harbor Island (2 specimens), and on Iroquois Island (1 specimen). One *Blarina* on Iroquois Island was white all around the posterior half of its body except for a small stripe continuing on the top of its back. Another individual on the same island had a circle of white around its body in the center of its abdomen. Still another individual had a white spot on its abdomen in addition to having a white tail tip.

Blarina were found on over half of the islands studied (Belle, Douglas, Harbor, Iroquois, Welcome, Wellesley) and the mainland. Apparently, *Blarina* is not able to cross large distances of water easily, for the most remote islands (Ironsides and Whiskey) were among those islands on which *Blarina* were not found. Ironsides Island seemed large enough to provide suitable cover, food, etc., for this species. Harbor Island, for example, is smaller than Ironsides, yet supports a population of short-tailed shrews. However, distance alone cannot be the factor explaining the absence of this species on such islands as Ironsides, for Ironsides is only 1950 feet from the mainland, and Crissey and Darrow (1949), Jackson (1920), and Dice (1925), all found *Blarina* on islands at least a mile from shore. Also, this shrew was found on Douglas Island, which is nearly as isolated as Ironsides Island. On the other hand, Hatt, *et al.* (1948) did not find it on islands in Lake Michigan which were four or more miles from the mainland.

The absence of *Blarina* from Kipp and Florence islands, small islands that are close to large islands with short-tailed shrew populations, suggests that perhaps island size also is an important factor in the distribution of this species on islands. If an island is very small, it is reasonable to assume that a *Blarina* population on it would also be small, and therefore could be extirpated by disease or other factors fairly easily. Thus any colony that becomes established could be removed quickly, resulting in only periodic habitation of the island by the species. Similarly, if a somewhat larger island, like Ironsides, were not quite large enough to permit a population of sufficient size to survive a low population point, the relatively great distance that it lies from shore would tend to decrease its chances for quick recolonization. Once again, the net result would be only periodic population of such an island by the species. The absence of *Blarina* from some of the islands studied may thus be due to temporary extirpation. Lack (1942) has pointed out this principle of temporary absence of species on islands in bird populations.

On some of the smaller islands, like Kipp and Whiskey islands, lack of sufficient food due to the small size of the islands might prevent the establishment of a colony except for very brief periods.

On Wellesley Island and on the mainland, *Blarina* was perhaps the most common mammal, being found in nearly every type of habitat. On Iroquois Island there was a distinct high in the population, at least on the southern part of the island, in 1953. The following year this shrew was still common, but by no means as abundant on this island. On Belle Island in 1953 there were approximately two colonies, each in a goldenrod thicket, to which they apparently confined themselves, for they were never trapped in any of the abundant grassy areas of the island where *Microtus* was common. In 1954, nearly two weeks of intensive trapping failed to reveal a single individual. In 1953, this shrew was not taken on Douglas Island, but was captured the following year, although in small numbers.

Myotis lucifugus lucifugus Le Conte. Little brown bat.—With its ability to fly, this animal could reach any of the islands, its distribution being limited only by suitable dwelling places. Specimens were collected on Wellesley and Iroquois islands. On Wellesley Island they were hidden between loosely juxtaposed roof rafters or other very narrow, dark places, often in clusters of four to eight. They were seen coming out of the barn at dusk, some of them darting into open spaces under the barn floor. There appeared to be no segregation

of the sexes, either here or on Iroquois Island, where the bats were collected in similar situations in the old boathouse.

Pipistrellus subflavus obscurus Miller. Eastern pipistrel.—The single specimen collected was taken August 14, 1953, in a mouse trap baited with peanut butter, set at the base of a cliff in a northern hardwood forest. It is not likely that it was caught accidentally in such a position, which indicates that this species may occasionally come to the ground to feed. Although this specimen was collected on the mainland, it is probably to be found on the islands too.

Lasiurus borealis borealis Miller. Red bat.—A single specimen was collected on Wellesley Island. It is probably found throughout the area where suitable conditions exist.

Procyon lotor lotor Linnaeus. Raccoon.—Raccoons were abundant on Wellesley Island, and their tracks were common on the mainland. On several occasions, two to four young raccoons were seen traveling together on Wellesley Island. A skeleton was found on Harbor Island with a shotgun pellet hole in its skull. No other sign of this species was found on Harbor Island or the other smaller islands.

Mustela erminea cicognanii Bonaparte. Bonaparte's weasel.—One specimen was taken along a small stream on Wellesley Island, while another was found as a road kill on this same island. No sign of this species was seen on smaller islands. There is a record (Davis, 1942) of a *Mustela frenata* swimming a river 40 feet wide. Weasels might also cross to islands on the ice.

Mephitis mephitis nigra Peale and Beauvois. Eastern skunk.—Road kills were frequent on Wellesley Island. There was no sign of this species on smaller islands.

Vulpes fulva Desmarest. Red fox.—This mammal is common on Wellesley Island and the mainland. There is no record of the red fox on the smaller islands, although residents report seeing them on the river during the winter months.

Marmota monax rufescens Howell. Woodchuck.—Road kills of this species are common along the road on Wellesley Island. They were frequently seen on the mainland also. One subadult was caught in a steel trap baited with flesh, and set in the water near a culvert.

Tamias striatus lysteri Richardson. Northeastern chipmunk.—Chipmunks were found only on Wellesley and Iroquois islands, in addition to the mainland. No sign of their presence was noted on the other islands, although some of them are as large as, and as near the shoreline as, Iroquois Island. Apparently winter inactivity deprives them of the opportunity to gain access to the islands by means of the ice. Since they occur on Wellesley Island, *Tamias* must have some opportunity to span the river upon occasion. Crissey and Darrow (1949) did not find the chipmunks on Valcour Island, one mile out in Lake Champlain, while Hatt, *et al.* (1948) found them on some islands in Lake Michigan at least seven miles from shore, but not on others equally far out nor on one island only one mile from shore. It would thus seem that their ability to be distributed across water is relatively poor, as is their ability to maintain populations on small islands.

Tamiasciurus hudsonicus loquax Bangs. Southern red squirrel.—It seems quite apparent that red squirrels either cross the ice to the islands during the winter, or swim to them. According to accounts by Hatt (1929), all islands in this region of the river would be within the swimming range of this species. That invasion of the nearby islands is frequent is indicated by the presence of a single squirrel on Florence Island in 1953. Here a male had made a nest and was feeding on white pine cones. Their distribution is sporadic, however. They are found on Douglas Island and the group of islands surrounding this island, but not on Ironsides Island. Yet this group of islands is as distant from a large land mass (Wellesley Island) and consequent reserve of red squirrels as is Ironsides Island. Furthermore, the Summerland Group (including Douglas Island) and Ironsides Island are ecologically similar.

The red squirrel was almost always found in association with white pine or hickory and oak woods. They were common on Wellesley Island in oak-hickory and oak woods, but on smaller islands they seemed to be concentrated around pines.

Sciurus carolinensis leucotis Gapper. Northern gray squirrel.—One melanistic indi-

vidual was observed on Wellesley Island. Gray squirrels were occasionally seen on the mainland and Wellesley Island, but never on the smaller islands. The fact that the forest type on the smaller islands is mainly northern hardwood may account for the absence of the species on these islands.

Glaucomys sabrinus macrotis Mearns. Northern flying squirrel. This species was collected only on Wellesley Island in an oak-hickory woods bordering the river.

Peromyscus leucopus noveboracencis Fischer. White-footed mouse. —This mouse was found on Iroquois, and Wellesley islands, and the mainland. It is to be noted that the distribution of this species on the islands studied is identical to *Sorex fumeus*, *Tamias striatus*, and *Sylvilagus floridanus*. Since this animal is active in the winter months, and since the habitats of the smaller islands are the types usually inhabited by this mouse, it is difficult to explain its restricted distribution. It frequently inhabits beach driftwood along the mainland, and several individuals were taken in such locations. Its absence from Ironsides Island is notable, especially since *Microtus* is so abundant on the island. It may be that the swimming ability of *Peromyscus* is poor compared to *Microtus*, although Orr (1933) reported a *Peromyscus maniculatus* crossing a swift-flowing stream ten feet wide with ease. It is more likely that *Peromyscus* requires more home range territory and therefore a larger island to sustain a permanent colony.

Crissey and Darrow (1949) did not take *Peromyscus* on Valcour Island in Lake Champlain. It is interesting to note that Hatt *et al.* (1948) found *Peromyscus maniculatus gracilis* on the islands in Lake Michigan, but did not find *Peromyscus leucopus noveboracensis*, although both forms are found on the mainland opposite these islands. The failure of the latter to reach the islands was explained as being due to the recency of its arrival in the area not giving it the opportunity to invade the islands.

Microtus pennsylvanicus pennsylvanicus Ord. Meadow mouse. —One aberrantly colored specimen was taken. An adult male on Welcome Island varied in having the bases of its hairs light cream colored rather than the usual plumbeous.

This mouse was found on every island studied. In two cases it was the only mammal found. It is doubted if Whiskey Island is large enough (0.8 acres) to sustain a colony of these mice indefinitely, since only two mice were taken there in 1953. Yet in 1954, two colonies of this species were found on Whiskey. *Microtus* was also the only mammal on Ironsides Island, which is entirely wooded. Not only was it present there, but it was abundant, despite the scarcity of herbaceous plants on which it might feed.

Microtus appears able to establish itself, and organize a colony rather readily. It gains access to the islands of the river, and can maintain itself in habitats it does not customarily occupy. The distance that *Microtus* can easily travel over water may be important in its distribution. Hatt *et al.* (1948) did not find *Microtus* on any of the 17 islands of Lake Michigan that they studied except one, which was 1.5 miles from shore. The next closest island was approximately seven miles from the mainland. Jackson (1920) found *Microtus* on islands in Lake Superior (Apostle Group) that were not more than 1.5 miles from the mainland. Crissey and Darrow (1949) also found the animal on Valcour Island in Lake Champlain, one mile from shore. This suggests that no island in the Thousand Islands area is too remote to be reached by *Microtus*.

Ondatra zibethica zibethica Linnaeus. Muskrat.—Although no specimens were collected, signs of this species were frequent in the numerous cattail areas along the shores of the river. One was seen in mid-day crossing a small canal between Wellesley and State islands. Another was observed on the smaller islands, but these shorelines had rocky habitat and did not provide either for suitable muskrat food nor habitat.

Rattus norvegicus Berkenhout. Norway rat.—Parts of the skull of one of these rats was found in an owl pellet on Florence Island. The remains of another specimen were also found on this island, and it too was probably a victim of predation. In 1953, there were holes and runways on Whiskey Island probably made by Norway rats. There was no sign of them there in 1954. On Belle Island there was no indication of them in 1953, but in 1954 fresh diggings were found that were probably made by rats.

Zapus hudsonius hudsonius Zimmerman. Meadow jumping mouse.—Although found only on the mainland, this species may well be on Wellesley Island also. Since it goes into hibernation before ice forms on the river, and emerges from its winter sleep long after the river is free of ice, its presence on the smaller islands is problematical.

Erethizon dorsatum dorsatum Linnaeus. Porcupine.—The porcupine is common in northern hardwood forests along the river. Some of the larger islands may possess this species, although no sign of it was seen on Wellesley Island. A porcupine mandible was found on Iroquois Island.

Sylvilagus floridanus mearnsi Allen. Eastern cottontail.—This rabbit was observed on the mainland and on Wellesley and Iroquois Islands.

Odocoileus virginianus borealis Miller. White-tailed deer.—The deer was not observed, but its droppings were found on the mainland two miles north of Alexandria Bay. Residents on Wellesley Island assert that deer have been shot on the island within recent years. Two fawns were reported seen on Wellesley Island in the spring of 1954.

DISCUSSION

Measurements and superficial characteristics of populations of various species from different islands have not shown significant differences from each other or mainland populations. It is interesting to note, however, that the few cases found of aberrant coloration (in *Microtus* and *Blarina*) were from island populations. In no case did such individuals constitute a significant part of the population.

Despite the large size and depth of the river in this area, it is usually frozen from the middle of December to late March. Of the 23 species of mammals noted in the region, 17 are active during the winter, and could utilize the ice as a means to invade the islands. Those animals that are inactive during the winter include bats, jumping mice, woodchucks, and chipmunks. Bats can fly to the islands during the summer, so that winter inactivity poses no problems of dispersal for them. Woodchucks may occasionally have opportunity to cross to islands on the ice, for they are active before the ice breakup.

In addition, woodchucks have been observed swimming streams up to 100 yards wide (Phillips, 1923; Cram, 1923; Robinson, 1923; Johnson, 1923). On the other hand, jumping mice hibernate before ice formation and emerge a month after the river is free of ice. Chipmunks might upon occasion be active on warm days in mid-winter and recommence activity in mid-March (Hamilton, 1943). Thus, all but jumping mice should be able to cross to islands on the ice. It may be, however, that some species, such as the smoky shrew would find such a journey quite perilous.

With these exceptions, geographic isolation alone cannot be the explanation or the small number of species on these islands. Rather, the number of species found on these islands appears to be correlated with the size of the island, ecological conditions, (especially substratum, vegetation, and food) reproductive potential, home range size, and dispersal ability, as well as the distance from the mainland or from other islands that are larger or nearer the mainland. The manner in which these factors operate upon different species is varied. *Blarina* and *Microtus* are both abundant on the mainland, but *Blarina* was found on only six of the islands studied, and was never common on the smallest islands, while *Microtus* were taken on every island, including islands in which the habitat was

unusual for the species and a normal one for *Blarina*. Hatt (1928) also found *Microtus* on an island only 600 feet from Valcour Island in Lake Champlain, which contained populations of both *Microtus* and *Blarina*.

On the other hand, both these species have been collected on relatively large islands no more than one and one half miles from the mainland, but neither species from other islands four or more miles out in lakes, in other studies (Jackson, 1920; Manville, 1951; Crissey and Darrow, 1949; Hatt, *et al.*, 1948). It would appear that the limit of easy dispersal over water is approximately the same for both animals, but that *Microtus* is more adaptable to smaller islands, and can maintain itself more readily both as an individual and as a species under such situations. Food requirements, size of home range needed, and reproductive potential may be some of the more important factors involved.

It is more difficult to understand the absence of *Peromyscus leucopus* and *Tamias striatus* from all the islands except Iroquois and Wellesley. These two species, and *Sorex fumeus* and *Sylvilagus floridanus* have identical distribution on the islands studied. The absence of the shrew may be due to lack of suitable habitat, or possibly inability to cross long distances of water or ice. Probably the former condition prevents rabbits from inhabiting the smaller islands, but neither of these explanations should be the reason for the absence of the other two species on islands such as Harbor, Douglas, and Ironsides.

Chipmunks were also absent on Valcour Island (Crissey and Darrow, 1949) and the Apostle Islands (Jackson, 1920), which were isolated by only one to one and one half miles of water, but were present on islands in Lake Michigan separated from the mainland by four or more miles of water (Hatt, *et al.*, 1948). However, this species was absent from small islands one mile or less from shore in Lake Michigan. Hatt (*loc. cit.*) concluded that its absence from the smaller islands is due to its inability to survive low points of population cycles. On the other hand, Manville (1950*a*) did not find *Tamias striatus* on Drummond Island (128 square miles) one mile out in Lake Huron.

Apparently the same conditions regulating the distribution of *Tamias* affect the distribution of *Peromyscus*, except that this species has been found on some small islands in Lake Superior (Jackson, 1920). Probably this smaller animal may not require quite as large an area to maintain a population, thus accounting for the difference in distribution of these two species. It certainly appears that both *Tamias* and *Peromyscus* do need a much larger area than does *Microtus* and *Blarina* in order to maintain populations.

Another factor that helps to determine the presence of species on islands is frequency of invasion, or ability of animals to cross water or ice to the islands. Flotsam is sometimes abundant on the river and could carry many of the smaller mammals. Variation in dispersal abilities would help to explain the presence of red squirrels, a good swimmer, on islands where *Tamias* and *Peromyscus* are absent, and may also be important in the distribution of *Blarina* and *Microtus* to nearby islands.

Raccoons and red foxes probably visit the islands, but only larger islands such as Wellesley could provide enough food for these animals for an indefinite period

of time. *Condylura* is apparently able to swim to many of the islands. Bourliere (1954) states that star-nosed moles are capable of swimming several hundred yards. However, no sign of this animal was found on Ironsides Island, although it was common on Harbor Island which is similar in habitat. Its range of easy dispersal over water may therefore be under 1900 feet. Palmer (1937) describes a situation where four subspecies of another mole (*Scapanus*) developed on islands in the Sacramento River.

SUMMARY

A survey of the Thousand Island Region was made from 1952 to 1954. Ten islands of varying size and isolation and the adjacent mainland were studied. Twenty-three species were recorded for the area, 17 of which were found on a large island. Two of the smallest and most isolated islands were populated only by *Microtus pennsylvanicus*.

With the possible exception of the hibernator, *Zapus hudsonius*, all the mammals in the area can probably gain access to all of the islands in this region of the river across the ice, on flotsam, or by swimming. Measurements and superficial characteristics of the various populations did not reveal incipient speciation on the islands. Differences in distribution of the various species on the islands is believed to be due to many interacting factors, chief among which are size of the island, degree of isolation, space requirements per individual, food requirements, habitat requirements, dispersal ability, reproductive potential, and winter activity.

Different species are restricted to islands of varying area and degree of isolation according to which of the other factors are more important to them. Thus *Microtus* may easily cross distances of one to one and a half miles, but needs only a small area in which to establish a colony because of a combination of the factors. *Blarina* may have about the same dispersal ability, but due to different requirements, apparently requires a larger island for a given degree of isolation, in order to establish a colony. Similarly, *Condylura*, *Tamiasciurus*, *Peromyscus*, *Tamias*, *Sorex*, *Sylvilagus*, and several species of bats have restricted distribution on the islands according to various requirements of these factors. Larger mammals may occasionally visit the smaller islands, but only one island of those islands studied was large enough to support populations of the other species.

LITERATURE CITED

Adams, C. C. 1909. An ecological survey of Isle Royale, Lake Superior. Lansing. 468 p.

Blair, W. F. 1946. An estimate of the total number of beach mice of the subspecies *Peromyscus polionotus leucocephalus* occupying Santa Rosa Island, Florida. Amer. Nat., 80: 665–668.

Bourlière, F. 1954. The natural history of mammals. Alfred A. Knopf, New York. 363 p.

Cram, W. E. 1923. Another swimming woodchuck. Jour. Mamm., 4: 256.

Crissey, W. F., and R. W. Darrow. 1949. A study of predator control on Valcour Island. N. Y. S. Conservation Dept., Research Series No. 1: 28.

Darlington, P. J. 1938. Origin of the fauna of the greater Antilles, with a discussion of dispersal of animals over water and through the air. Quart. Rev. Biol., 13: 274–300.

DAVIS, W. B. 1942. Swimming ability of two small mammals. Jour. Mamm., 23: 99.

DICE, L. R. 1925. The mammals of Marion Island, Grand Traverse County, Michigan. Occ. Papers Mus. Zool., Univ. of Mich., no. 160: 1–8.

HAMILTON, W. J., JR. 1943. The mammals of eastern United States. Comstock, Ithaca, N. Y. 432 p.

HATT, R. T. 1928. The relation of the meadow mouse *Microtus pennsylvanicus pennsylvanicus* to the biota of a Lake Champlain island. Ecology, 9: 88–93.

———. 1929. The red squirrel: its life history and habits, with special reference to the Adirondacks of New York and the Harvard Forest. Roosevelt Wild Life Annals, 2(1): 4–146.

HATT, R. T., J. VAN TYNE, L. STUART, C. H. POPE, AND A. GROBMAN. 1948. Island life: a study of the land vertebrates on the islands of eastern Lake Michigan. Cranbrook Inst. Sci., Bul. 27, 179 p.

HINTON, M. A. C. 1931. Rats and mice as enemies of mankind. Ed. 3, Brit. Mus., Econ. Ser. 8: 1–70.

JACKSON, H. H. T. 1920. An apparent effect of winter inactivity upon distribution of mammals. Jour. Mamm., 1: 58–64.

JOHNSON, C. E. 1923. Aquatic habits of the woodchuck. Jour. Mamm., 4: 105–107.

LACK, D. 1942. Ecological features of bird faunas of British small islands. Jour. Animal Ecol., 11: 9–36.

MANVILLE, R. H. 1950*a*. The mammals of Drummond Island, Michigan. Jour. Mamm., 31: 358–359.

———. 1950*b*. A comparison of trapping methods. Jour. Mamm., 31: 377–383.

———. 1951. A small island community in midsummer. Ecology, 32: 608–617.

MARSHALL, W. H. 1940. A survey of the mammals of the islands in Great Salt Lake, Utah. Jour. Mamm., 21: 144–159.

ORR, R. T. 1933. Aquatic habits of *Peromyscus maniculatus*. Jour. Mamm., 14: 160.

PALMER, F. G. 1937. Geographic variation in the mole *Scapanus latimanus*. Jour. Mamm., 18: 280–314.

PHILLIPS, J. C. 1923. A swimming woodchuck. Jour. Mamm., 4: 256.

PRUITT, W. O. 1951. Mammals of the Chase S. Osborn Preserve, Sugar Island, Michigan. Jour. Mamm., 32: 470–472.

ROBINSON, W. 1923. Woodchucks and chipmunks. Jour. Mamm., 4: 256–257.

Biology Department, Blackburn College, Carlinville, Illinois. *Received November 29, 1955.*

NOTES ON THE MAMMALS OF JACKSON COUNTY, INDIANA

By Russell E. Mumford and Charles O. Handley, Jr.

When Lyon published his MAMMALS OF INDIANA (Amer. Midl. Nat., 17: 1–384, 1936), Jackson County was represented by only a single specimen (*Cryptotis parva*) and a few sight records, despite its location in a taxonomically important part of the State. Mumford's residence in the county from June 7, 1952, until August 1, 1954, and occasional visits through April, 1955, gave opportunity for gathering additional data. Since other field work had priority, no intensive mammal survey could be attempted, but, as time permitted, collections and observations of mammals were made. Most trapping was conducted at the edge of the hill region near Freetown, with lesser amounts near Vallonia and Brownstown. Some selective trapping was done in small isolated habitats to capture species not found in other situations. Unfortunately, many habitats could not be adequately sampled.

Handley identified the specimens, most of which are now in the United States National Museum (US). A few are in the Joseph Moore Museum, Earlham College (J); in the Chicago Natural History Museum (C); and in the private collections of Philip Kahl (K), Mumford (M), and Alex Walker (W). Handley also examined 704 mammal items from owl pellets gathered at Starve Hollow Lake and near Houston, three and one-half miles northwest of Freetown.

Topography.—Jackson County, located within the unglaciated, hill region of south-central Indiana, is nearly rectangular, about 520 square miles in area, and varies from about 490 to 940 feet in elevation. The western and northwestern one-third of the county is rough and hilly, traversed by a series of northeast-southwest ridges. With the exception of the White and Muscatatuck River bottoms and scattered ridges and high "knobs" southeast of Brownstown, much of the remainder of the county is rolling.

Most of the county is drained by the East Fork of the White River, a large stream transecting the county from northeast to southwest. The two forks of the Muscatatuck River drain the southeastern part of the county, and Salt Creek drains the northwestern portion. There are occasional sloughs and bayous along the larger streams, but the largest body of water is Starve Hollow Lake, an artificial impoundment created about 1939 two miles southeast of Vallonia. It has an area of 170 acres.

The county is without caves of consequence, and data on bats are thus rather meager. Nevertheless, summer bat populations are high in some areas. On the evening of June 21, 1952, for example, over 80 small bats were observed along a 1.5 mile stretch of road between Starve Hollow Lake and Vallonia. It was possible to see from 12 to 15 bats in the air at one time.

Bushnell (THE STORY OF INDIANA SOILS, Agric. Exper. Sta., Purdue University, 1944) reported that the soils of Jackson County are sandy loams, silt loams, stony loams, clay, and fine sand. By his classification, soil regions H, J, L, and O are present.

Vegetation.—Most of the county was originally forested with hardwoods, but was logged off near the turn of the century. Much of the present wooded area,

about 50 per cent of the county, is composed of small to medium-sized trees, often with a dense understory. Such woodlands are heavily populated with squirrels and are utilized by the gray fox and white-tailed deer. The roughest terrain is fairly well timbered with oak-hickory and beech-maple timber types, while tulip poplar and black walnut are also common forest trees. In earlier times, chestnut was probably plentiful. On the higher "knobs" and ridges, chestnut oak predominates.

Many of the flat-topped and relatively broad ridges were cleared by early settlers for home sites and crop land. Since the mid-1940's, many of these have gone out of cultivation and are reverting back to broom grass, sassafras, briars, sumac, and other brushy vegetation. A number of such areas, some of them badly eroded, are now owned by the United States Forest Service and the Indiana Division of Forestry, and have been planted to pines.

River bottom timber is primarily sycamore, cottonwood, red elm, silver maple, beech, sweet gum, and pin oak. Much of the wooded bottomland along the Muscatatuck River floods periodically, thus is swampy in nature. Here, in the so-called "crayfish flats," stands of pin oak and sweet gum are prevalent. Because of the difficulty of drainage, little of this bottomland is cultivated, and much brushy cover is available. The raccoon, mink, red fox, and cottontail probably reach their greatest abundance in this section of the county.

Most primitive marshland has been destroyed, but a few small, poorly-drained spots persist. Marsh habitat also has become established about the borders of Starve Hollow Lake and some of the larger farm ponds.

SPECIES ACCOUNTS

Didelphis marsupialis Linnaeus. Opossum.—This was a common species in all parts of the county, as evidenced by the observation of several individuals and a dozen road kills. One (J) was captured on a road four miles north of Freetown on the night of December 6, 1953, and the skull of a male (US) was picked up on a road near Freetown, March 26, 1954. The subspecies here is probably *D. m. virginiana* Kerr.

Blarina brevicauda kirtlandi Bole & Moulthrop. Short-tailed shrew.—For some reason this shrew was not common in the county. None was trapped and only two skulls were present among the 270 mammals represented in owl pellet material. One (US) was found dead on August 12, 1953, on a dirt road that crosses a high ridge between Freetown and Kurtz. The site was an overgrown, brushy field with sassafras, dogwood, sumac, and broom grass predominating. Another specimen (US) was collected by Raymond J. Fleetwood at Kurtz in May, 1933.

Typical *Blarina b. carolinensis* Bachman apparently occurs in Indiana only along the Ohio River in the extreme southwestern part of the State, whence we have examined a specimen (US) from Cypress Junction, Vanderburgh County. Other specimens in the U. S. National Museum from New Harmony, Corydon, and Bascom (Rising Sun) are considerably larger, but nevertheless referable to *carolinensis*. Specimens from Bicknell and Kurtz are still larger and are nearer *kirtlandi*, which occurs in nearly typical form in the northern half of the State.

Cryptotis parva parva Say. Least shrew.—Lyon (*loc. cit.*) recorded a specimen (US) that Fleetwood captured in "freshly dug post holes" at Kurtz, April 29, 1932. Although none was trapped during the recent period, the remains of 11 were recovered from owl pellets. Indiana specimens are not distinguishable either by size or coloration from topotypes of *parva*.

Scalopus aquaticus machrinus Rafinesque. Eastern mole.—This species appeared to be common in practically all habitats. Eleven were collected or were found dead. A male (US) was taken March 20, 1953, in a runway on a lawn 2 miles northeast of Freetown. On August

26, 1953, another male (US) was captured by hand 2.5 miles north of Freetown as it tunneled in extremely hard, dry soil along a dry wash in beech-maple woods.

Myotis lucifugus lucifugus LeConte. Little brown bat.—During rather intensive collecting of bats by shooting, near Freetown, no little brown bats were taken. However, a male (US) was shot two miles west of Seymour, along the White River, on the evening of August 6, 1952, and a female (US) was shot 1.5 miles southeast of Vallonia, June 21, 1952, as it fed along a road with *Pipistrellus subflavus*.

On June 18, 1953, Mumford investigated a report of bats in the attic of a house two miles northeast of Cortland and found a breeding colony. The favorite roost of the bats in this attic—around a brick chimney—showed signs of long usage, for droppings had accumulated to a depth of ten inches immediately below. The people living in the house stated that bats had utilized the attic for at least 50 years. In 1953 and 1954, 395 bats were banded from this colony, but it probably contained at least 500 individuals, since many could not be captured. Females were in the majority; for example, on April 30, 1954, 102 females and 3 males were banded. Four females captured June 14, 1954, were carrying single young estimated to be one to three or four days old. Only one of 15 females banded on June 18, 1953, was carrying an offspring. Two adults and eight juveniles (J, M, US) were preserved.

Pipistrellus subflavus subflavus F. Cuvier. Eastern pipistrelle.—This was a common species in the summer, and 22 specimens (C, J, K, M, US), many of which were immature, were shot. Collection dates ranged from June 21 to August 13. In addition, two pipistrelles were found in an old, abandoned cabin southwest of Maumee on May 5, 1954. They hung from the ceiling, about seven feet high, among loose and hanging strips of old wallpaper.

A gravid female that was shot and only slightly wounded on June 21, 1952, near Vallonia, was kept in captivity for observation. Mrs. Mumford noted no young at 11:30 AM on June 25, but at 2:40 PM the female hung with thumbs attached to the top of the cage and feet clinging to the side, with two newborn young lying in the pocket formed by her upturned tail membrane. One of the young was dead, apparently stillborn. It dropped to the floor at 2:47 when the female succeeded in severing its umbilical cord with her teeth. The female spent considerable time licking the live young and her own body, but at 2:54 she descended to the cage floor and briefly licked the dead individual. She then crawled about, eating the placenta and chewing on the umbilical cord still attached to the live young. At 3:00 the young extended one foot, then the other, and grasped the side of the cage. Here it hung, while the female moved away, stretching the umbilical cord to a length of about one inch. Soon, however, the female returned to lick the young, which had been making "sucking" sounds with its lips. The young one then nuzzled the female's breast and may have begun nursing, for the female hung quietly for three minutes. By 4:05 the cord holding the young had nearly been severed, as the female alternately chewed it, preened the young and herself, crawled about over the cage, and rested. The cord came free at 4:24, when both animals were picked up for examination. The young uttered a weak, squeaking cry throughout the observations. Mother and young died on June 27, and all were preserved (J) in alcohol.

Eptesicus fuscus fuscus Beauvois. Big brown bat.—This species was possibly more common than the few records indicated. On February 16, 1953, Mrs. Mumford and son, James, found a dead *Eptesicus* on a sidewalk in Seymour. An adult male that was roosting behind a window shutter near Cortland was banded July 28, 1954. A female (M) with a broken wing was captured in the Indiana State Highway Garage, Seymour, January 20, 1954. None was observed in flight during two summers of bat shooting near Freetown.

Lasiurus borealis borealis Müller. Red bat.—This bat was commonly recorded from March 13 to November 16 (both dates in 1953). Six of the 23 specimens (J, M, US, W) collected were immatures. An adult female, shot June 7, 1954, contained four fetuses with crown-rump length of 18 mm. Other females were found to have three fetuses. Several red bats were captured with a hand net as they flew over a small watering pool.

Lasiurus cinereus cinereus Beauvois. Hoary bat.—A subadult female (US) was shot at dusk on July 18, 1952, along a small stream two miles northeast of Freetown. It was moving northward, at a height of 15 feet, with a rather slow, steady flight, unlike the driving, erratic flight of adults. This record indicates that the species possibly breeds in the county.

Sylvilagus floridanus J. A. Allen. Cottontail.—Cottontails were scarce in most parts of Jackson County during the hunting seasons of 1952–54. A relatively small number of road kills reflected the low population. Where there was abundant cover along small stream valleys, some hunters reported more rabbits than in upland areas. The subspecies here is possibly *S. f. mearnsii* J. A. Allen.

Sciurus carolinensis carolinensis Gmelin. Gray squirrel.—Much of the rough, wooded area of the county is ideal for gray squirrels, and they were abundant during the period of observation. One male (J) and one female (US) were collected. The measurements of the latter, an adult in summer pelage, place it well within the limits of the southern subspecies *carolinensis*: Total length 445 mm., tail vertebrae 178 mm., hind foot 61 mm., condylobasal length 54.4 mm., greatest length of skull 61.3 mm., maxillary tooth row 10.4 mm., and zygomatic breadth 33.7 mm.

Sciurus niger rufiventer E. Geoffroy. Fox squirrel.—Common. Fox and gray squirrels were found together in many areas, but in woodlots and more open and grazed woodlands, fox squirrels predominated. A single specimen (J) was preserved.

Marmota monax monax Linnaeus. Woodchuck.—This species was common in all parts of the county. On September 4, 1953, Harold Bunch shot a very fat female (J) that weighed 16 pounds.

Tamias striatus ohionensis Bole and Moulthrop. Eastern chipmunk.—In wooded areas and along brushy fencerows chipmunks were found to be fairly common. Females were collected on August 11, 1952, (J) and September 17, 1953, (US). The former contained four small fetuses.

T. s. ohionensis appears to be a poorly differentiated race, intergrading in most of its range with one or more contiguous races. However, it seems to be recognizable on the basis of large size; buffy or yellowish, rather than grayish, back and shoulders; and pale rump, in some specimens scarcely differentiated from the color of the flanks. Cranial measurements of the National Museum specimen are: Greatest length 43.4 mm., interorbital breadth 11.9 mm., zygomatic breadth 23.7 mm., and nasal length 15.0 mm.

Glaucomys volans volans Linnaeus. Southern flying squirrel.—Flying squirrels were no doubt more common than the few observations indicated. Two individuals took up residence in a martin house near Freetown during the summer of 1953 and used it intermittently until March, 1955. A female (US) collected there on April 14, 1954, contained three 9-millimeter embryos. One was identified from an owl pellet.

Castor canadensis Kuhl. Beaver.—Data on the disappearance of beavers from the county are lacking. Some individuals have been introduced in recent years in Starve Hollow Lake. Two that were captured there during the 1953–54 fur season weighed 48 and 42 pounds, respectively.

Peromyscus leucopus noveboracensis Fischer. White-footed mouse.—This species was found in all habitats sampled by trapping. Twenty-five specimens (J, US) were saved. Based on a small number of trap nights, it appeared that the white-footed mouse was the most abundant small mammal in the pin oak-sweet gum flats. One hundred and thirty-four *Peromyscus*, not determined to species, were represented in the owl pellet material. Theoretically, *Peromyscus maniculatus* may have been represented in this material, although none was secured by trapping.

Synaptomys cooperi cooperi Baird. Lemming mouse.—Seven specimens (J, US) were trapped between January 9, 1953, and January 31, 1954, at three abandoned house sites, and seven were represented in the owl pellet material, collected at two additional stations. Since the points of collection were widely separated, it is proable that *Synaptomys* occurred throughout the county in suitable habitat.

The house sites were all well-drained clearings that were reverting back to briars and brush. *Synaptomys* runs were located in dense bluegrass. Typical runs often emerged from the cover of grass, continued for a short distance on top of the grass, then disappeared again beneath it. The runs were not barren, as those of *Microtus* usually are, but were lined with living bluegrass.

A lemming mouse spent several weeks in the fall of 1953 in a nest under a large piece of

TABLE 1.—*Measurements (in millimeters) of some Indiana specimens of Synaptomys cooperi in the U. S. National Museum*

Locality Museum number Identification	Width of upper incisors	Nasal width	Condylo-basilar length	Zygo-matic width	Skull height	Total length (skin)
Porter Co., Hebron 141767 *gossii*	3.8	3.6	25.3	16.3	10.1	123
Newton Co., Roselawn 141741 *gossii* (subadult)	3.5	3.4	25.3	—	9.6	—
Pike Co., Winslow 298455 *gossii*	3.8	3.4	25.6	17.2	10.5	130±
Clark Co., Henryville 298456 *gossii*	3.6	3.6	25.7	16.5	10.3	122
Harrison Co., Corydon 300678 (intermediate between *gossii* & *cooperi*)	3.4	3.2	24.8	15.6	9.5	117
Jackson Co., Freetown & Houston (average of 6) 296639–41, 297799–01 *cooperi*	3.5	3.2	24.2	16.1	9.6	115

corrugated metal roofing lying on the ground. The nest was almost globular and was composed of dry grass. Runs radiated out under the roofing from the nest to the surrounding grass. At this site, the farm house had burned down in the spring of 1952, and the remains of the old bluegrass lawn were lush and tall.

We follow Wetzel (Jour. Mamm., 36: 1, 1955) in identifying Jackson County specimens as *S. c. cooperi*, rather than *saturatus* or *stonei* as previous authors have done. Numerous specimens of *S. c. cooperi* from Franklin, Jackson, Lawrence, and Ohio counties agree very well with the data presented by Wetzel (*loc. cit.*). Additional specimens from extreme southern and western Indiana which Wetzel did not see prove to be referable to the western subspecies *S. c. gossii*, not previously reported in Indiana. External dimensions are large, and skulls are large, broad, and massive in these specimens (Table 1).

Ondatra zibethicus Linnaeus. Muskrat.—Although the muskrat was fairly common around farm ponds and along the streams of the county, houses were evident only in the areas of cattail bordering Starve Hollow Lake. Elsewhere, bank dens apparently were the rule.

During the fur season of 1953–54, state employees trapped 98 muskrats at Starve Hollow Lake. The 1954–55 harvest was halted in mid-season, after about 75 rats had been taken, for the trappers noted that the animals averaged very small. This might be evidence of late litters. The breeding cycle may have been altered when the lake level was lowered about six feet for several weeks in the spring of 1954 to allow construction of new boat docks. One specimen (J) was preserved. The subspecies here is probably *O. z. zibethicus* Linnaeus.

Microtus ochrogaster ochrogaster Wagner. Prairie vole.—This vole was plentiful in all habitats trapped except woods and marshes. It seemed equally abundant in abandoned fields of broom grass and in cultivated fields. With 87 individuals accounted for, this species ranked second to *Peromyscus* in occurrence in owl pellets. Eighteen specimens (J, US) were preserved.

Microtus pennsylvanicus pennsylvanicus Ord. Meadow vole.—Persistent trapping in small, marshy areas around ponds yielded four specimens (US) of this species. In March, 1954, runs were abundant in a small, generally wet cattail-sedge marsh at the western edge of Vallonia. One male and two females were taken there on March 27. One of the females had two uterine young that measured 16 mm. in crown-rump length. The following day, another male was trapped in a cattail-sedge area at the marshy border of a farm pond two miles northeast of Freetown. In addition, 19 individuals were represented in the owl pellet material.

Rattus norvegicus Berkenhout. Norway rat.—This common pest was found about farm buildings, in the cities, and around roadside garbage dumps. Tracks were noted along the White River. One specimen (J) was preserved.

Mus musculus Linnaeus. House mouse.—In addition to being abundant around farm

buildings, many of these mice occurred in open fields. Five specimens (J, US) were preserved, and the remains of 14 were found in owl pellets.

Vulpes fulva Desmarest. Red fox.—Hunters, trappers, and farmers agreed that the red fox had been abundant for several years. Four were observed during the period of study and two road kills were recorded. During the year 1953, the county auditor paid bounties on 472 foxes. Unfortunately, no record was kept of the relative abundance of red and gray foxes, but the auditor was of the opinion that reds outnumbered grays about 10 to 1. The nominate race probably occurs here.

Urocyon cinereoargenteus Schreber. Gray fox.—The fact that the gray fox is more restricted to the wooded hill region than the red fox, may account for the relatively small number of grays turned in for bounties. The rougher sections of the county are more thinly inhabited by farmers; thus, fewer gray fox dens are located. During this study Mumford observed four gray foxes in the Ewing and Freetown areas. Donald Waggoner shot a male (J) near Kurtz on August 31, 1953. Its stomach contained a *Microtus*, corn, and a dozen large grasshoppers.

On May 8, 1954, Chester Scott brought Mumford three pups, two males and one female, which his dog had found in the base of a large, hollow beech stub, four miles northeast of Freetown. Thinking the dog had treed a woodchuck, Scott probed up through the hollow with a pole, forcing the adult gray fox to jump from the top of the tree. On the following morning each of the young weighed 15 ounces. Probably the nominate race occurs here.

Procyon lotor Linnaeus. Raccoon.—Very abundant during the period of the study. Many were found dead on roads. A trapper near Brownstown told Mumford that he had captured 81 raccoons during the period November 15–December 4, 1953, and complained that they spoiled his mink sets. Another trapper caught 21 raccoons in his traps along a three-quarter mile stretch of the White River between November 15 and December 28, 1954. Probably the nominate race occurs here.

Mustela frenata Lichtenstein. Long-tailed weasel.—This species apparently was not common, and many old trappers and hunters said they had seen few in the past 15 years. Ray Bennett recalled that he and another man obtained seven under an old stump near Freetown some years ago. Franklin Brothers, fur buyers in Seymour, purchased 12 to 15 weasels during the fur season 1953–54, but had obtained only two from the county prior to December 21 in the 1954–55 season. None of these pelts was white, although this firm normally receives a few in the white winter pelage each season. Franklin Brothers thought weasels were decreasing. Mumford secured a male (M) weasel (weight 7 ounces, stomach empty) that had been brought to Franklin Brothers on December 18, 1954. The subspecies here is probably *M. f. noveboracensis* Emmons.

Mustela vison mink Peale and Beauvois. Mink.—Single mink were observed along the White River below Brownstown on October 24 and November 4, 1952. Two skulls (US), taken from skinned-out carcasses found along a road 2 miles north of Vallonia on November 28, 1953, were preserved. Trappers reported fair success in trapping in this area, especially in the 1952–53 and 1953–54 seasons. During both years, ditches and smaller streams draining into the White River dried up or became very low, perhaps forcing mink to the larger body of water.

Mephitis mephitis Schreber. Striped skunk.—During June and July, 1952, three skunks were observed in weed fields during the daytime and three others were found dead on roads. Up to February 21, 1954, eight additional road kills were recorded in various parts of the county. The subspecies here is probably *M. m. nigra* Peale and Beauvois.

Odocoileus virginianus Zimmermann. White-tailed deer.—No data are available to indicate the date of disappearance of native deer from the county. Nineteen animals, released in 1941, built up a herd of considerable size. However, four successive hunting seasons and poaching at all seasons took their toll. With adequate protection and less hunting pressure, this herd should increase, since food and cover are abundant.

Museum of Zoology, University of Michigan, and U. S. National Museum, Washington, D. C. Received November 17, 1955.

SYNAPTOMYS COOPERI IN KENTUCKY, WITH DESCRIPTION OF A NEW SUBSPECIES

By Roger W. Barbour

The scarcity of Kentucky specimens of *Synaptomys* in the recent papers of Hall and Cockrum (1953) and Wetzel (1955) have prompted the author to put on record his findings relative to the status of *Synaptomys cooperi* in Kentucky.

Welter and Sollberger (1939) were apparently the first to record *Synaptomys cooperi stonei* Rhoads from Kentucky. They recorded two specimens from a swampy area near Morehead, Rowan County. Barbour (1951) was the second to record the species, with his five specimens from the summit of Big Black Mountain, in Harlan County. These are apparently the only two published accounts of the occurrence of the species in the state.

The zoological collections of the University of Kentucky currently contain 86 specimens of *Synaptomys cooperi* from Kentucky, collected by the author and his students, largely since 1950. A series of 16 specimens from Mason County was borrowed from the private collection of Mr. James T. Wallace of Maysville. Three specimens from Rowan County were borrowed from the zoological collection of Morehead State College. Mr. Dwight M. Lindsay, of Georgetown College, Georgetown, Kentucky, kindly lent a series of 13 specimens of *Synaptomys cooperi* from Ripley and Jefferson counties, Indiana. Credit is due the Research Fund Committee of the University of Kentucky for financial assistance incident to the collection of many of the specimens.

We have found *Synaptomys* rather easy to trap, particularly in the months of January, February and March. At this time in Kentucky, at least, the ground is relatively free of snow cover, and the tall grasses that constitute the habitat of *Synaptomys* are rather limited in distribution, confined largely to fence rows, swampy areas, and the relatively few waste fields. At this time of year, the population of *Synaptomys* is concentrated in such areas, and snap-back mouse traps set across the runs will take numerous specimens. We regularly bait our traps with a mixture of peanut butter and rolled oats, but this is of apparently little value in trapping *Synaptomys*. In April and May rapid growth of grasses occur, greatly extending the available range for *Synaptomys*, hence making the colonies much more difficult to locate. They can readily be taken in summer and fall, provided one can locate the colonies. Naturally, such a trapping technique results in the capture of other species; in the Bluegrass area of Kentucky, these are largely *Microtus ochrogaster*, *Pitymys pinetorum*, *Peromyscus maniculatus bairdii*, and *Blarina brevicauda*. In areas of Kentucky where *Microtus* does not occur, one may be quite certain that surface runs in thick stands of grass are those of *Synaptomys*, though *Pitymys*, with their more fossorial habits, will occasionally be taken. At the summit of Big Black Mountain in Harlan County, runways in heavy stands of grass, at least in March, will frequently yield *Peromyscus m. nubiterrae* and *Clethrionomys gapperi maurus*, as well as *Synaptomys*.

In the following accounts, all measurements, except where otherwise noted, are given in millimeters. Averages are given first, followed by extremes in parentheses.

Synaptomys cooperi stonei Rhoads

Characteristics.—We have 23 specimens of this race from Kentucky. They average slightly larger than the measurements of *stonei* from the Southern Appalachians, as given by Wetzel (1955). Our specimens average: Total length, 128.8 (107–152); tail, 21.1 (16–26); hind foot, 20.2 (16–22).

Distribution in Kentucky.—Known from the counties of Clay, Elliott, Harlan, and Rowan. This subspecies, in Kentucky, is apparently of widespread distribution in the eastern mountainous section of Kentucky (Fig. 1). It does not extend into the Outer Bluegrass region to the west, but its westward distribution in the more rugged counties to the south of the Bluegrass area is unknown, and is a matter of continuing research.

Habits.—As is well known, this species is a creature of colonial habits. Frequently a rather extensive area of apparently excellent *Synaptomys* cover will have only a small colony located somewhere within it, with no apparent reason for such distribution.

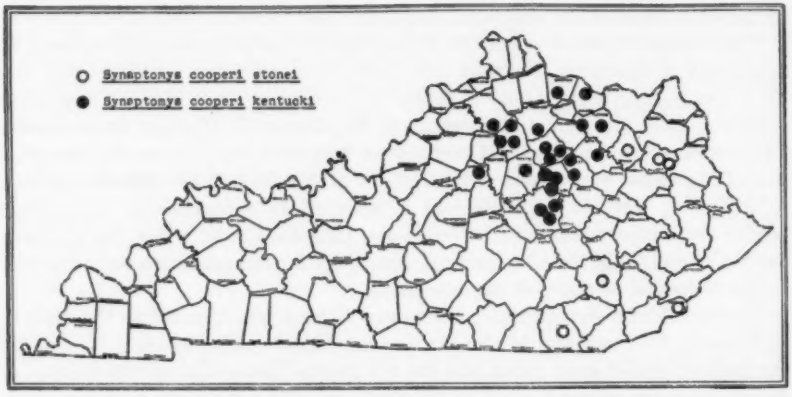


FIG. 1.—Locality records of *Synaptomys cooperi* in Kentucky.

In Kentucky, *Synaptomys* appears to be strictly a grassland form. If this be so, the occurrence of the species in a field of some 100 acres at the summit of Big Black Mountain in Harlan County poses an interesting problem. This field is apparently a natural opening, but it is completely surrounded by several miles of woodland.

The runways resemble those of *Microtus*, but are generally not so well-worn. Nests, softball size, are occasionally found at the surface of the ground, generally well-hidden under a tangle of grasses. We have not seen the young, but a female taken February 22 in Elliott County contained two full-term embryos.

Specimens examined.—Twenty-three specimens of *Synaptomys cooperi stonei* from Kentucky were examined, distributed by counties as follows: Clay 2 (Garrard, 2); Elliott, 4, (three miles northwest of Isonville, 3; two miles west of Dewdrop, 1); Harlan, 10, (summit of Big Black Mountain, elevation 4000 ft., near Lynch, 10); Rowan, 4 (Morehead, 4); Whitley, 3 (Gold Bug, 3).

Our series of 82 *Synaptomys cooperi* from the Bluegrass area of Kentucky is readily separable from any described form, and apparently represents an undescribed subspecies, for which is proposed the name:

Synaptomys cooperi kentucki new subspecies

Type.—Male, adult, skin and skull, United States National Museum number 301891. Collected at Sadieville, Scott County, Kentucky, on February 23, 1953, by Dwight M. Lindsay. University of Kentucky number 1964.

TABLE 1.—*Comparative skull measurements of 41 Synaptomys cooperi from Kentucky. Averages are given first, followed by extremes in parentheses*

	Maxillary tooth row	Condylo-basilar length	Nasal length	Zygomatic width	Lambdoidal width	Skull height
S. c. kentucki (30 specimens)	6.7 (6.2–7.0)	23.3 (20.1–24.9)	6.9 (5.6–7.5)	15.2 (13.0–16.0)	12.7 (11.3–13.4)	9.2 (8.2–9.7)
S. c. stonei (11 specimens)	7.4 (6.8–7.8)	25.2 (24.3–26.3)	7.5 (6.9–7.9)	16.3 (15.8–17.4)	13.2 (12.8–13.8)	9.8 (9.4–10.2)

Type locality.—Sadieville, Scott County, Kentucky.

Range.—The Inner Bluegrass region of Kentucky, and at least the eastern half of the Outer Bluegrass region (Fig. 1).

Diagnosis.—Size small (see measurements), the smallest of the races of *Synaptomys cooperi*. Upper parts in winter pelage near Cinnamon Brown (capitalized terms are those of Ridgway, 1912), but vary from near Hazel to Bister. Dorsally the pelage is interspersed with black hairs, giving a grizzled appearance. Ventrally, the animals are generally Pale Smoke Gray; but vary from almost white to near Pale Ochraceous-Buff. June specimens are much darker dorsally, due largely to a greater admixture of black hairs.

Measurements.—The type specimen has the following measurements: Total length, 109; tail, 21; hind foot, 20; length of maxillary tooth row, 6.75; width of upper incisors, 3.5; condylobasilar length, 22.75; length of incisive foramen, 4.0; nasal length, 7.0; nasal width, 3.5; rostral length, 6.0; rostral width, 5.25; zygomatic width, 15.5; lambdoidal width, 12.75 and height of skull, 9.5.

Average measurements of 76 specimens of both sexes, including the type, are: Total length, 117.2 (94–132); tail, 18.9 (14–26); hind foot, 18.8 (16–21). Average skull measurements of 30 specimens from well distributed localities are: Length of maxillary tooth row, 6.7 (6.2–7.0); width of upper incisors, 3.4 (2.9–3.8); condylobasilar length, 23.3 (20.1–24.9); length of incisive foramen, 4.4 (3.8–5.0); nasal length, 6.9 (5.6–7.5); nasal width, 3.5 (2.8–4.0); rostral length, 6.0 (5.2–6.7); rostral width, 5.4 (4.9–5.9); zygomatic width, 15.2 (13.0–16.0); lambdoidal width, 12.7 (11.3–13.4); height of skull, 9.2 (8.2–9.7).

The more diagnostic of these measurements with comparative measurements of a small series of *S. c. stonei* from Kentucky are shown in Table 1.

Comparisons.—From *Synaptomys cooperi stonei*, the subspecies to the east, *S. c. kentucki* may be separated by its smaller size, and smaller, more slender skull. The color differences in these two subspecies are slight, *kentucki* being slightly less chestnut. From *Synaptomys cooperi cooperi*, the subspecies immediately to the north and west (assuming Wetzel's 1955 analysis to be correct), *kentucki* may be readily separated by the fact that it is considerably more chestnut (hence less gray) than *cooperi*. In size, *kentucki* compares favorably with *cooperi*, but averages slightly smaller. If it should develop that *Synaptomys cooperi saturatus* Bole and Moulthrop is the subspecies immediately to the north and west, *kentucki* is readily separable from this form on the basis of its smaller size and lighter coloration.

Relationships.—*Synaptomys cooperi kentucki* represents a form occupying the area between the ranges of *S. c. stonei* and *S. c. cooperi* where these do not overlap, as outlined by Wetzel (1955). It intergrades with *stonei* along the eastern border of the Outer Bluegrass region of Kentucky, and with *cooperi* along the northern border of the Outer Bluegrass region. These areas of intergradation are relatively narrow, and the population of north-central Kentucky represents a clear-cut geographic unit, closely knit, and, although exhibiting many characteristics in common with *cooperi* and *stonei*, remains separable as a unit from either of them, except in the narrow regions where the ranges overlap.

A series of seven specimens from a rugged section of Owen County, almost due west of

the type locality of *ken'ucki*, shows affinities, both in size and coloration, with *cooperi*. However, they are apparently more closely related to *kentucki*, and are so considered.

Specimens examined.—Eighty-two specimens of *Synaptomys cooperi kentucki* were examined, distributed by Kentucky counties as follows:

Anderson, 1, (one mile east of Lawrenceburg, 1); Bath, 2, (three miles east of Owingsville, 2); Bourbon, 5, (North Middletown, 1; 4.5 miles south of Paris, 1; .8 miles north of the Clark County line on US Highway number 227, 3); Bracken, 8, (one mile north of Milford, 8); Clark, 6, (one mile west of Winchester, 2; 6 miles west of Winchester, 2; Winchester water works, 2); Fayette, 1, (Lexington, 1); Fleming, 3, (Nicholas County line on Kentucky Highway number 32, 1; two miles west of Flemingsburg, 2); Harrison, 1, (one and one-half miles west of US Highway number 227, on Silas Creek, 1); Madison, 7, (three miles northeast of Waco, 1; three miles east of Waco, 1; four miles east of Waco, 1; one mile north of Redhouse, 1; four miles north of Redhouse, 2; Richmond, 1); Mason, 18, (Maysville, 18); Montgomery, 3, (one mile northwest of Sideview, 1; two miles west of Mt. Sterling, 1; Mt. Sterling, 1); Owen, 7, (Kleber Sanctuary, two miles north of the Franklin county line on Kentucky Highway number 368, 7); Scott, 20, (three miles north of Georgetown, 3; three miles east of Georgetown, 2; four miles northeast of Georgetown, 3; two miles east of White Sulphur, 3; four miles northeast of Oxford, 2; five miles north of Stamping Ground, 1, Stamping Gound, 1; and Sadieville, 5).

Remarks.—We have been able to find no habit or habitat differences between *kentucki* and related forms. We have taken eight pregnant females between January 10 and March 21. The average number of embryos was 2.6, varying from two to four. Generally the smaller mbryos were found earlier in the year, but a female taken February 15 contained two nearly ull term embryos.

LITERATURE CITED

BARBOUR, R. W. 1951. The mammals of Big Black Mountain, Harlan County, Kentucky Jour. Mamm., 32: 100–110.

HALL, E. R. AND E. L. COCKRUM. 1953. A synopsis of the North American microtine rodents. Univ. of Kans. Publ., Mus. of Nat. Hist., 5: 373–498.

RIDGWAY, R. 1912. Color standards and color nomenclature. Published by the author, Washington, D. C., iii + 43 pp., 53 pls.

WELTER, W. A. AND D. E. SOLLBERGER. 1939. Notes on the mammals of Rowan and adjacent counties in eastern Kentucky. Jour. Mamm., 20: 77–81.

WETZEL, R. M. 1955. Speciation and dispersal of the southern bog lemming, *Synaptomys cooperi* (Baird). Jour. Mamm., 36: 1–20.

Department of Zoology, University of Kentucky, Lexington. Received October 28, 1955.

GERBILS FROM IRAQ, WITH DESCRIPTION OF A NEW GERBIL

By David L. Harrison

A number of gerbils and sand rats belonging to the Sub-family Gerbillinae were obtained by the author in Iraq during the period from August, 1953, until March, 1955. The species obtained are listed below with some notes on their characteristics and field habits.

GENUS *GERBILLUS*

The Palaearctic gerbils are divided into two subgenera, the one with naked soles of the hind feet (Subgenus *Dipodillus*), the other with the soles of the feet wholly or partially hairy (Subgenus *Gerbillus*). Ellerman (1947), in his revision of the Palaearctic species admitted ten valid species in the region.

Examination of my own material and comparison with that in the National Collection reveals two naked-soled forms existing in Iraq, which differ from each other in several respects. As both these forms have a small tympanic bulla and there is at present no evidence that their distribution overlaps, it is considered likely that the new form from Iraq here described will prove to be a subspecies of *Gerbillus* (*Dipodillus*) *dasyurus* Wagner. I propose to name it:

Gerbillus (Dipodillus) dasyurus mesopotamiae, ssp. nov.

As Type specimen of this new form I nominate an adult female in my collection (No. 4.1737) obtained on January 16, 1955, near Amiriya, on the west bank of the Euphrates, south west of Faluja, Iraq. This is a medium-sized gerbil in which the soles of the feet are quite naked. The general build and proportions are similar to *G. d. dasyurus*, but the tail of this animal possesses only a small terminal pencil and the short hairs covering the rest of the tail are noticeably coarser. The general colour of the dorsal surface is darker than in most gerbils and considerably darker than in *G. d. dasyurus*, in this animal it is near to Wood Brown of Ridgway (Plate 3, No. 19), slightly tinged with russet on the dorsal aspect of the muzzle and with a greyish tint over the crown of the head and shoulders. The hairs of the back are grey at the bases, tipped with brown. There is a distinctive facial colouration. A prominent white patch behind and above the eye is sharply contrasted with a larger black patch situated behind the eye and extending back to the base of the external ear and up to the commencement of the anterior border of the pinna (Fig. 1). The anterior part of the cheeks, throat, chest and belly are pure white, the hairs being white to their bases and the line of demarcation along the flanks well defined. The dorsal aspect of the hands and feet is whitish, the tail buffy brown above, paler below, with only very slight darkening of the small terminal pencil.

The main cranial characters are similar to *G. d. dasyurus* and in particular the tympanic bulla is approximately the same size. There is however, a much more marked expansion of the zygoma along its junction with the zygomatic plate in this animal, becoming sharply narrowed posteriorly. In addition the lacrymal bones are decidedly larger in this animal, than in *G. d. dasyurus*.

As Paratypes I nominate ten specimens in my collection (Nos. 2.1735, 3.1736, 5.1738, 6.1739, 7.1740, 8.1741, 9.1742, 10.1743, 11.1744, 12.1745) obtained near Amiriya and in the belt of country extending several miles to the northwest along the Euphrates, on its west bank, which thus becomes the *terra typica*. This series are similar in all essential respects to the Type, varying somewhat in the amount of greyish suffusion on the back and in the development of the black facial patch which is absent in some specimens. Data on measurements is presented in Table 1.

This interesting gerbil is represented by eleven specimens in my collection all of which

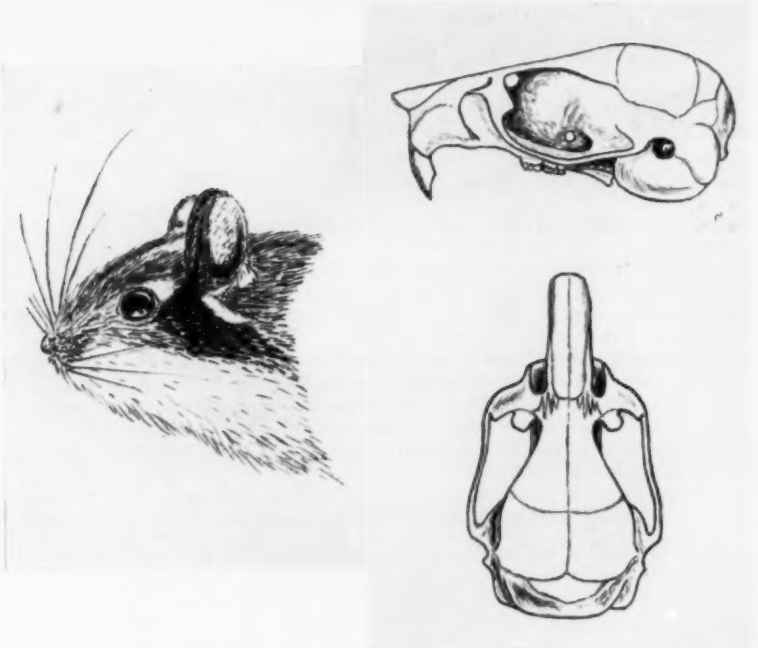


FIG. 1.—LEFT: Facial Pattern of *G. d. mesopotamiae*. 1½ times natural size. Drawn by D. L. Harrison.

RIGHT: Skull of *G. d. mesopotamiae*. Vertical and lateral views, 2 times natural size, showing anterior part of zygomatic arch expanded in the dorsoventral plane and the large lacrymal bones. Drawn by D. L. Harrison.

TABLE 1.—*Measurements of the Type and two Paratypes in millimeters*

Measurement	Type No. 4. 1737	Paratype No. 3. 1736	Paratype No. 5. 1738
Total length	185.5	205.6	172.8
Forearm	21.3	24.3	23.8
Hindfoot	21.2	22.8	23.2
Tail	102.0	112.5	99.5
Ear	13.5	12.9	13.0
Condylobasal length	23.9	24.5	23.3
Zygomatic breadth	14.8	15.2	—
Breadth of braincase	12.8	12.9	12.8
Depth of braincase	9.1	9.9	9.3
Lacrymal breadth	8.3	9.0	8.8
Mandible	13.2	12.8	13.1
Greatest anteroposterior diagonal diam. bulla	9.4	9.7	9.2
Maxillary tooth row	3.1	3.2	3.3
Mandibular tooth row	3.4	3.2	3.3

differ from *G. d. dasyurus* in respect of their darker general colouring, the peculiar facial markings present in the majority, the smaller pencil and coarser hair of the tail, and in the skull the more widely expanded antero-lateral aspects of the zygomatic arches (expanded in the dorso-ventral plane) and larger lacrymal bones (Fig 1.). An examination of the material in the British Museum revealed five skins and six skulls of *G. dasyurus* from Baghdad and Amara which appear to be referable to *G. d. mesopotamiae*, having similar tail, cranial features, and colouring, and lacking only the black facial patch, which appears to be a variable and perhaps purely local characteristic. Gerbils referable to typical *G. d. dasyurus* in the National Collection are from Sinai (Type locality Tor), Palestine and several localities in Saudi Arabia. One specimen from the Syrian Desert about 200 kms. east of the Dead Sea and another in my own collection obtained east of Rutba (*Vide infra*) shows that *G. d. dasyurus* extends into the Syrian Desert and actually occurs in W. Iraq. The form described here, *G. d. mesopotamiae*, is found along the Rivers Tigris and Euphrates in central and southern Iraq. Its relationship with *G. d. dasyurus* is at present unknown, there being no evidence either of intermediation or overlap (Fig. 2). It is a very distinct form, but until more evidence becomes available regarding this relationship, the form described here is best regarded as a subspecies of *G. dasyurus*.

The peculiar facial pattern noted as occurring in the Amiriya gerbils is of some interest, for a paler greyish facial patch in the same situation occurs in *G. gerbillus allenbyi* Thomas (1918), which occurs in Palestine. This is a hairy-footed gerbil, apart from a small patch on the heel. A less well pronounced dark facial patch is present in a specimen of *G. nanus macgilligini* in the National Collection from Egypt, this species having naked soles but much larger tympanic bullae. It seems possible that such a facial pattern is a primitive character in the genotype (in the genetic, not the systematic sense) of the gerbil group. Figure 1 illustrates a Paratype of *G. d. mesopotamiae* that has this facial pattern developed to a pronounced degree. It is emphasised, however, that this should not be regarded as an essential character of the form.

G. d. mesopotamiae is a colonial animal. A large number of burrows were found on sandy hillocks at the edge of the desert where this impinged on the edge of the fertile land along the river at Amiriya. The mounds were covered with the dried remnants of an annual plant,

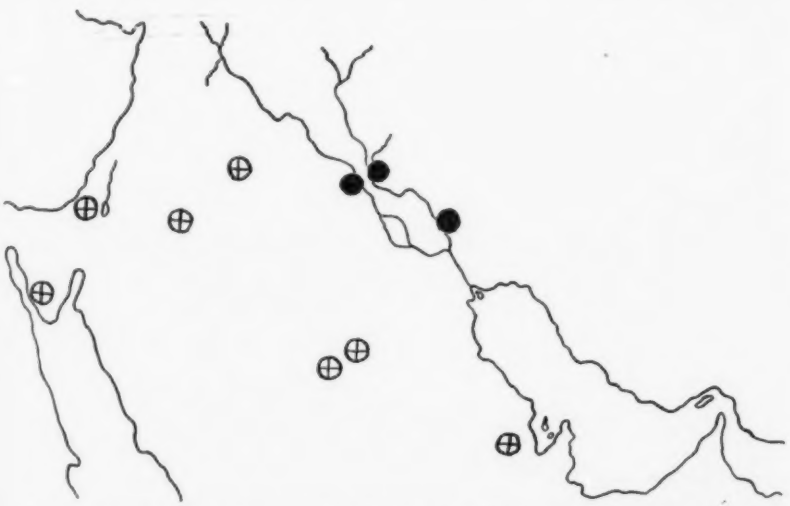


FIG. 2.—Map showing the known distribution of *G. d. dasyurus* and *G. d. mesopotamiae* in Northern Arabia. Crossed circles indicate *G. d. dasyurus*; filled circles, *G. d. mesopotamiae*.

and the burrows were found over several acres of this terrain (Pl. I). The mice were crepuscular and nocturnal in habit, appearing, as the light faded, to dart from one system of burrows to another. Some specimens were obtained by trapping at the entrance of the burrows, using cheese as a bait, while others were excavated from the burrows during the daytime. The burrows were mainly shallow and extended sometimes for a distance of ten feet or more, with several exits. The burrows were not plugged with earth at their entrances. Buxton (1923) records that *G. dasyurus* does sometimes plug its burrows in Mesopotamia and he found it in association with *Suaeda* bushes there. Some burrows appeared to contain no nest chamber, and when one was present it was usually at greater depth, a little over three feet and often beneath the centre of a mound, the nest being composed of the dried shoots of coarse desert herbs. The burrows often contained blind side tunnels that were packed for a distance of six inches with stores of the dried seeds of the plant covering the mounds. We several times excavated a species of toad that used the gerbil's burrows, and a single colony of *Meriones lybicus* was found in the same area in association with a clump of a spiny perennial shrub. A specimen of this gerbil was found co-habiting the burrows of these sand rats. *Gerbillus cheesmani* was found in the same general area, but not in the same locality. An adult female *G. d. mesopotamiae* was captured on December 18, 1954, and found to be pregnant carrying five embryos (Crown-Rump length about 12 mm.).

Gerbillus dasyurus dasyurus Wagner.—One example of this subspecies was trapped by M.A.C. Stephenson on January 18, 1954, about seven miles south southeast of H 2 Pumping Station in the Syrian Desert east of Rutba. This is in all features comparable to the typical form, being a pale sandy colour with a well-marked dark tuft to the tail. Unfortunately the zygomatic region of the skull was destroyed in the trap.

This specimen was obtained by trapping with cheese in a rocky wadi bed in stony hills in the Syrian Desert about 1500 feet above sea level. The wadi bed contained grass and other herbs. The gerbil had been active during the night in spite of great cold, the temperature falling well below freezing point.

Gerbillus cheesmani cheesmani. Cheesman's gerbil.—This elegant gerbil is represented in my collection by thirteen examples collected in the area of the Haur al Hasa and Amiriya, along the west bank of the Euphrates, south west of Faluja, Iraq. They were obtained in March, 1954, and from November, 1954, until February, 1955. It is a larger species than the preceding one (Hind foot in this series 25.8–27.8 mm.) and it is at once distinguishable by its pale pinkish buff colouring above, with long silky fur. The soles of the feet are covered with short whitish hairs, except for a very small area on the heels, and the tympanic bullae are greatly expanded. There is therefore no difficulty in distinguishing between the three forms of gerbil now known to occur in Iraq. It is quite possible that further collecting in this relatively little-studied area may yet reveal more species there.

Cheesman's gerbil was recorded in THE SURVEY OF IRAQ FAUNA (1923) from the Basra-Nasariyeh Railway. The present specimens appear to be the most northerly record of it in Arabia.

It is a strictly nocturnal species. One of my examples was trapped with cheese as bait in sandy terrain on the desert edge of the Haur al Hasa. The remainder were obtained at night, often long after dark, when they were seen running about in the open in the headlamps of a vehicle amongst sandy hummocks with very sparse vegetation. Their colouring is extremely well adapted to this terrain, making them extremely difficult to detect unless they happen to move. It appears to be much more solitary in habit than the preceding species.

GENUS *MERIONES*

Meriones crassus charon Thomas.—This sand rat is represented by four specimens in my collection obtained at the Haur al Hasa on February 28, 1954, near Samarra (west bank of the Tigris) on November 20, 1954, and two obtained for me by J. Davison from Jazira Desert, about twenty miles southwest of Samarra, near Section 3 of the Wadi Thar Thar Project on January 6, 1955. It was recorded in THE SURVEY OF IRAQ FAUNA (1923) from Khazimain, Baghdad and from Beled on the Tigris.

This is the smallest of the three species of *Meriones* now known to occur in Iraq (Hind foot of these examples 25.2-28.9 mm.). It is also distinguished from the next species (*M. lybicus*) by the normal flesh-coloured soles of the feet and internal aspects of the external ears in the present animal. Its tympanic bullae are greatly inflated. It is variable in colour, one of my examples from the Haur al Hasa being pale sandy brown above while another from Jazira is very grey brown above.

This species is mainly active by night and one example was shot running about in headlights illumination on very exposed sandy ground. At the Haur al Hasa the burrows of this animal were constructed in large sandy hummocks surmounted by a species of thorny perennial bush, a situation very similar to that in which I found the larger typical form, *M. c. crassus*, in Oman, (Harrison, in press). A trap was placed in the entrance to one of these burrows at 2:00 PM local time, that is, in full daylight, baited with cheese. This caught a rat within half an hour, while I was still in the vicinity setting others. No other colonies were located in the Haur al Hasa area, but a colony of *M. lybicus* was found in a similar habitat several miles further south.

Meriones lybicus syrius Thomas.—This Sand Rat is represented by fourteen specimens in my collection from Iraq. Four were obtained near Amiriya in January, 1955, and ten from Jazira Desert, south west of Samarra, near Section 2 of the Wadi Thar Thar Project on January 29, 1955. Ellerman and Morrison-Scott (1951) mention the presence of *M. l. syrius* in Iraq and there is a specimen from Zubeir, S. Iraq in the British Museum. Specimens from Amiriya in my collection are closely comparable to a topotype from Karyatein, Syrian Desert, in the National Collection. This species is immediately distinguishable from the preceding one by it's much heavier build (Hind foot in my series 33.8–37 mm.), while the soles of the feet are dusky blackish in colour as are the internal aspects of the ears. These features readily separate even juvenile individuals. The nails also are dark and the black tuft of the tail is heavier than in *M. crassus* and extends for a greater distance up the tail. The tympanic bulla of this species also is greatly enlarged.

This species is evidently mainly diurnal in habit. In Jazira, near Samarra a large colony was found, the animals running about and feeding in the open and in the full sunlight at

PLATE I

Habitat of *G. d. mesopotamiae* at Amiriya, Iraq. Photo by D. L. Harrison.

midday. When running fast the tail is held erect at an angle of ninety degrees to the body. Their holes were beneath clumps of perennial bushes but there were many outlying holes in smaller hummocks covered by coarse grasses and other annual herbs. At Amiriya the members of a small colony found in a similar hummock emerged from their holes at dusk, so that the species is also crepuscular at times. An adult and three half-grown young were found when this burrow was excavated in mid-January.

Meriones persicus Blanford. Persian sand rat.—The occurrence of this species in Kurdistan, N. Iraq has been recorded by the author in a separate paper (Harrison, in press). It is a large species (Hind foot 38.6 mm.) with a prominent bushy tip to the tail, pale greyish in colour, with a relatively small tympanic bulla in the skull, in contrast to the two preceding species. It is an inhabitant of rocky, mountain slopes at considerable altitude.

GENUS *TATERA*

Tatera indica Hardwicke. Indian gerbil.—One specimen is in my collection, obtained on the east bank of the Euphrates, near Habbaniya, Iraq on January 25, 1955. The forms *Tatera bailwardi* and *Tatera pitmani* regarded as synonymous with this species by Ellerman and Morrison-Scott (1951) were recorded in THE SURVEY OF IRAQ FAUNA (1923) from Baiji, near the Fatah Gorge, Tigris, Shahroban, Sheikh Saad, Lake Akkar Kuf near Baghdad, Amara and Sinn Abtar Kut. It therefore appears to be widespread in Iraq.

It is a heavy rat-like gerbil, with a black tufted tail in which the black colour extends up the tail both dorsally and ventrally, leaving a pale lateral area on each side of the tail. Cranially it is distinguished by the extreme forward projection of the zygomatic plate and rather small tympanic bullae.

Its burrows are large and made in sandy ground. This specimen was obtained by pouring water down the hole.

Acknowledgments—I am very grateful to my friends and colleagues of the Medical Officers Mess, R.A.F. Habbaniya, who assisted me greatly in obtaining the specimens, especially Wg. Cdr. D. S. Grant, S. Ldr. S. Seligman, F. Lt. J. A. McGeoch and F. Lt. R. E. Partridge. I am also much indebted to Mr. J. Davison, Mr. J. France and Mr. A. Bickley of the Wadi Thar Thar Project for their kind assistance and help and to Mr. M. A. C. Stephenson who helped me in the collection and preparation of specimens. His Excellency Akram Ahmed, Mutasarif of Dulaim Liwa and Mr. Mohammed Hamza of Ramadi also gave me invaluable help.

LITERATURE CITED

BUXTON, P. A. 1923. Animal life in deserts. E. Arnold Ltd., London: 103.

CHEESMAN, R. E. 1923. Survey of Iraq fauna. Mammals: 1–24.

ELLERMAN, J. R. 1947. Notes on some Asiatic rodents in the British Museum. Proc. Zool. Soc. London, 117. Pt. 1: 261.

ELLERMAN, J. R. AND MORRISON-SCOTT, T. C. S. 1951. Checklist of Palaearctic and Indian mammals. British Museum Publication.

HARRISON, D. L. 1955. On a collection of mammals from Oman, Arabia. Ann. Mag. Nat. Hist., Ser. 12, vol. 8: 897.

HARRISON, D. L. 1956. Mammals from Kurdistan in N. Iraq and Description of a New Bat. Jour. Mamm., 37: 257–263.

ON TWO MOUNTED SKELETONS OF *MEGALOCNUS RODENS*

By Carlos de Paula Couto

While in the United States, in 1951, on a fellowship of the John Simon Guggenheim Memorial Foundation, I had my attention attracted by the important collection of ground-sloth fossil material from the Pleistocene of Cuba, stored in the Department of Geology and Paleontology of The American Museum of Natural History, in New York. Part of that collection was made by the late Dr. Carlos de La Torre, in 1910, in the locality of the Ciego Montero thermal springs (Baños de Ciego Montero, a well-known health resort of Cuba) Provincia de Las Villas, the same spot where a student of the University of Cuba, José de Figueroa, discovered, in 1861, the first specimens of *Megalocnus rodens*, type of the species. Specimens were collected also in fissure springs in the Sierra de Jatibonico, from which de La Torre secured a considerable, although fragmentary, collection of fossil bones of *Megalocnus* and crocodiles.

In 1911, Mr. Barnum Brown, of The American Museum of Natural History, with Dr. de La Torre's help, completed the exploration of the Casimba de Jatibonico localities, collecting a few additional bones. From Sierra de Jatibonico they went north to Caibarien, thence southwest to Remedios (locality of former paleontological discoveries) and finally traveled south to Ciego Montero, where a large collection of fossil bones was obtained without exhausting the springs, since a great deal of material remained in the surrounding clays. The exploration of the Ciego Montero springs was finally completed by Mr. Brown in a later expedition, in 1918.

In 1919, Dr. William Diller Matthew published two notes on the fossil Antillean mammals (Matthew, 1919*a*, *b*) and, finally, in 1931, a posthumous note on the ground-sloths of the Pleistocene of Cuba was published by The American Museum of Natural History on the basis of Matthew's incomplete manuscript (Matthew, 1931).

In 1951, my interest in the collection of ground-sloth material from the Pleistocene of Cuba coincided with a request of the Museo Poey de la Universidad de Havana to have the greater part of the collection returned to Cuba. Through the courtesy of Dr. George Gaylord Simpson, chairman of the Department of Geology and Paleontology of The American Museum of Natural History, who was interested in having the whole collection studied as a series before being broken up, I was able to go over the collection and to complete Matthew's important manuscript on the Cuban edentates, which is now almost ready for the press. On conclusion of the study, about fifty good specimens of all the Cuban species of ground-sloths were sorted and returned to the Museo Poey de la Universidad de Havana. With authorization of Dr. José Alvarez Conde, then director of the museum of Havana, a small collection was sent to the Museu Nacional do Rio de Janeiro, to be exchanged for fossil Pleistocene material from Brazil.

The fossil remains of *Megalocnus rodens* collected by Mr. Barnum Brown and Dr. Carlos de La Torre in Ciego Montero, although unassociated, were enough

to permit the assemblage of two composite skeletons which are shown in the exhibition halls of The American Museum of Natural History in New York, and the Museo Poey de la Universidad de Havana. They are composed of topotypes of *Megalocnus rodens*. The work of assembling both the skeletons and making the mounts was accomplished by Mr. A. Herrmann, former technician of the Laboratory of Vertebrate Paleontology of The American Museum of Natural History. The present paper is a preliminary note concerning these two mounted skeletons of *Megalocnus rodens*.

I want to thank Dr. George Gaylord Simpson and The American Museum of Natural History for the opportunity given me to complete Matthew's observations on that important collection. A grant from the Conselho Nacional de Pesquisas, Rio de Janeiro, permitted me to devote full time to this research. The assistance given me by the Conselho also made possible the fine illustrations of Mr. Ulisses Bastos Freitas, whom I also want to thank for his excellent work.

SYSTEMATICS

Order Edentata Cuvier, 1798
Suborder Xenarthra Cope, 1889
Infraorder Pilosa Flower, 1883
Superfamily Megatherioidea Cabrera, 1929
Family Megalonychidae Zittel, 1892
Subfamily Megalocninae Kraglievich, 1923

Megalocnus Leidy, 1868.

Megalocnus Leidy, 1868, p. 180.
Megalonyx (*Myomorphus*) Pomel, 1868, p. 665.
Megalochnus Ameghino, 1881, p. 303 (invalid emendation or misspelling).
Megalonyx, Lydekker, 1887, p. 111 (including "Megalochnus"-*Myomorphus*), *nec* Harlan, 1825.
Megalonyx (*Megalochnus*), Zittel, 1894, p. 136.
Parocnus Miller, 1930, in part (?).
Genotype: *Megalocnus rodens* Leidy, 1868.

Diagnosis.—Teeth 5/4, the first upper and lower pair enlarged and spaced as in *Megalonyx*, but approximated medially, flattened into a scalproform type, broadly convex anteriorly, concave posteriorly; the cheek teeth like those of *Megalonyx* but longer. Palate greatly depressed in relation to the basicranial axis, much as in the Glyptodontia. Condyles much elevated above tooth row; anterior border of coronoid process between second and third molars. Limb bones as in Santacruzean megatherioids. Humerus with large entepicondylar foramen. Manus as in Santacruzean forms, but metacarpals less differentiated, and unguals long, slender, comparatively straight and but little compressed (mainly after Matthew, in Matthew and Paula Couto's "The Cuban Edentates," ms.).

The skeleton in The American Museum of Natural History is mounted in quadrupedal or walking position (Fig. 1), and the skeleton exhibited in the Museo Poey de la Universidad de Havana is in a semi-erect position, having its fore feet applied against the stock of a tree.

The skull and mandible of *Megalocnus rodens* resemble particularly those of the tree-sloths of today, and the glyptodonts, by their general shape. They are more globose, in conjunction, than elongate. The zygomatic arch is widely open, the jugal bone being slender and reduced (the figure of the skull, in Scott, 1937: 664, Fig. 396, is erroneous in showing a closed zygomatic arch). The teeth are very like those of *Megalonyx*, but the front ones are more specialized, somewhat rodent-like. The neck is relatively elongated, the body somewhat heavy. The ilium is broad, but much less expanded anteroposteriorly than in *Megal-*

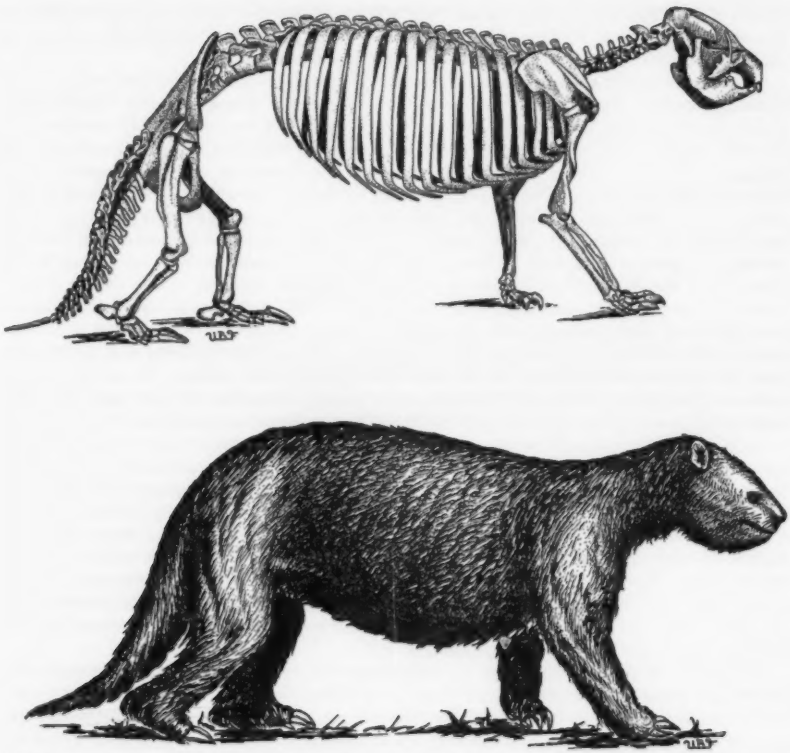


FIG. 1.—TOP: *Megalocnus rodens* Leidy. Skeleton from Ciego Montero, Cuba. (After a photograph of the composite specimen shown in The American Museum of Natural History.) BOTTOM: *Megalocnus rodens* Leidy. Restoration based on the skeleton in The American Museum of Natural History.

onyx and *Paramylodon*, for example, recalling that of *Nothrotherium* in this aspect. The tail is rather short. The limb and foot characters are much as in the Miocene (Santacruzean) relatives (*Hapalops*, etc.) but with elongate ungual phalanges. They are very primitive and unspecialized. The morphology of the astragalus shows that the animal, like the ant-eaters (*Myrmecophaga*), had no tendency to walk upon the outer side of the pes, as is the case with the continental Pleistocene relatives; the pes, as the manus, was plantigrade (Fig. 1). The skeleton, in general, is most like that of the Santacruzean megalonychids, but somewhat more massive, although not nearly so much as in *Megalonyx*.

Megalocnus is the most specialized genus of the West Indian group, and of its family in general. It includes the largest and most abundant of the Antillean species of the group, *Megalocnus rodens*, the size of which was about, or a little larger than, that of an American black bear (*Ursus americanus*). Its weight would have been about 600 pounds (270 kilos) in the fully adult condition.

According to Matthew, the West Indian ground-sloth genera may all be derived from a single invading ancestral type, *Eucholoeops* or some near ally, reaching the Antilles by passive way in Miocene or early Pliocene times, and there specializing into the several

genera of the Pleistocene (so far as one may judge from the diversity in its late Pleistocene descendants, and from their structural relations to the progressive evolutionary stages of their continental relatives in the Tertiary and Pleistocene history).

It seems to me that this is, indeed, the most plausible hypothesis for the origin of the Antillean genera, since all them (*Acratocnus*, *Mesocnus*, *Microcnus*, and *Megalocnus*), although very specialized present, as it is known, primitive features closely recalling the Miocene (Santacruzean) ancestors, such as *Eucholoeops*, *Hapalops*, and *Schismotherium* of Patagonia. Their evolution, as generally true with the evolution of all the insular or insulated animal groups, was bradytelic relative to that of the continental ground sloths. In the ground sloths the evolving rate, although not so slow, was nevertheless slower than the common or standard rate, as exemplified by the evolution of the Holarctic and Sonoran mammalian groups in general. Otherwise, all the characteristic mammalian groups of the Cenozoic of the Neotropical Region in South and Central America, where the ecological roles were divided between marsupials and more or less archaic placentals (edentates, protungulates, and paenungulates of primitive aspect) although differentiated in a relatively large number of zones of adaptive radiation, seem to have evolved at a slower rate than the contemporary groups in the Holarctic and Sonoran regions. These latter were more successful, "probably because they were already the selected survivors of a long series of intermigrations with Eurasia while South American mammals had been evolving in isolation" (Simpson, 1953*a*: 26). South America, we must remember, was an isolated continent during most of Tertiary times, developing in that time a particular fauna. This was derived, at least in its greater part, from pre-Cenozoic primitive North American ancestors. The land bridge between South and North America, that is, the Panama Isthmus of today, is supposed to have been broken up (submerged) by the end of Mesozoic times (upper Cretaceous, perhaps contemporaneously with the Laramide diastrophism) or the beginning of Cenozoic times (lower Paleocene), and to be restored (reemerged) by the middle or the end of the Pliocene epoch (possibly due to the Cascadian diastrophism which was responsible for the last uplift of the Rocky Mountains, paralleled, it seems, by the last important uplift of the Andean chain).

Megalocnus rodens was certainly the most conspicuous element of the Pleistocene fauna of Cuba. Its ecological affinities must have been different from those of the larger representatives of the same great group (Megatherioidea) in the Pleistocene of the continent, since it had to adapt itself to a relatively small number of rather static, closed ecological niches (Simpson, 1953*b*: 306). It was perhaps preferentially an inhabitant of the humid dense tropical forests in the mountains or forested plateaus and valleys or along the banks of water streams.

Its smaller relatives and contemporaries in the Pleistocene of Cuba, such as *Acratocnus* and *Microcnus* may have been tree-dwellers, as are the tree-sloths (*Bradypus*, *Choloepus*) of today. The hypothesis that a better knowledge of these smaller forms would perhaps indicate some closer degree of relationship to the Bradypodoidea than it is admitted today is not completely out of probability.

LITERATURE CITED

AMEGHINO, F. 1881. La Antiguedad del Hombre en el Plata, 2: 1–557. Paris-Buenos Aires.

LEIDY, J. 1868. Notice of some vertebrate remains from West Indian Islands. Proc. Acad. Nat. Sci. Philadelphia, 20: 178–180.

LYDEKKER, R. 1887. Catalogue Fossil Mammalia. British Mus. (Nat. Hist.), 5: I–XXXV, 1–345.

MATTHEW, W. D. 1919*a*. Recent discoveries of fossil vertebrates in the West Indies and their bearing on the origin of the Antillean fauna. Proc. Amer. Philos. Soc., 58: 161–181.

———. 1919*b*. Affinities and origin of the Antillean mammals. Bul. Geol. Soc. Amer., 29: 657–666.

———. 1931. Genera and new species of ground sloths from the Pleistocene of Cuba. Amer. Mus Novitates, 511: 1–5.

POMEL, A. 1868. Sur le *Myomorphus cubensis*, sous-genre nouveau du *Megalonyx*. Comptes Rendus Hebdomadaires des Séances Acad. Sc. Paris, 67, 13: 665–668.

SCOTT, W. B. 1937. A history of land mammals in the Western Hemisphere. The Macmillan Co., New York. 1–786.

SIMPSON, G. G. 1953*a*. Evolution and geography. Condon Lectures Publ. 1–64. Eugene, Oregon.

———. 1953*b*. The major features of evolution. Columbia Univ. Press, New York. 434 p.

ZITTEL, K. A. VON. 1894. Traité de Paléontologie, I, 4: 1–806. Paris, Munich and Leipzig.

Museu Nacional, Rio de Janeiro, Brazil. Received December 16, 1955.

GENERAL NOTES

NOTES AND BLOOD DATA ON SOME SMALL MAMMALS OF DURHAM COUNTY, NORTH CAROLINA

These data were gathered during the investigation of another problem (Foreman, J. Cell. and Comp. Physiol. 44: 421–430, 1954). The trapping was conducted with the sole aim of collecting, alive, specimens of as many of the indigenous species of small mammals as possible. The rodents were of primary interest, and the author sought as many different habitat types as he could find in the area. Those trap sites that happened to yield a species poorly represented in the area were trapped repeatedly. Each trap was set where it was thought to be most likely to catch the desired species, and no effort was made to take random samples or otherwise measure relative or absolute population densities.

The traps were made of $\frac{3}{16}''$ wire mesh, and the doors and rocking type treadles were made of thin galvanized iron. The traps were 3.5″ x 3.5″ x 12″. The bait used was a mixture of rolled oats and peanut butter; occasionally a little beef suet was added. Most of the trapping was done in the Duke University Forests, but some sites were selected at other places in the county. The trapping extended from January 7 to June 23, 1953.

Blood for the data in Table 1 was drawn from the heart with a 20 gauge needle into a 2 ml. syringe containing a minute amount of powdered heparin. It was then transferred immediately into a small paraffin dish from which it was pipetted as rapidly as the appropriate apparati could be manipulated.

The red cell counts were made according to the clinical procedure described by Wintrobe (CLINICAL HEMATOLOGY. Ed. 3, 1951) using Gower's solution for diluting. A Spencer Bright-line Haemacytometer was used.

Hematocrits were determined with a special microhematocrit tube which was a modification of a type described by Van Allen (Jour. Amer. Med. Assoc., 84: 202–203, 1925).

Total hemoglobin content was measured on an Evelyn Colorimeter in accordance with a technique published by Hall (*in* Consolazio, Horvath, and Dill. n.d. SYLLABUS OF METHODS OF THE FATIGUE LABORATORY. Harvard University. p. 71). Mean red cell diameters were determined upon dry smears using a microscope and a Bausch and Lomb Filar Micrometer eyepiece.

The catch for 1712 trap-nights using a total of 42 traps was as follows: *Peromyscus leucopus*, 139; *Sigmodon hispidus*, 27; *Reithrodontomys humulis*, 15; *Peromyscus nuttalli*, 13; *Pitymys pinetorum*, 10; *Blarina brevicauda*, 10; *Microtus pennsylvanicus*, 5; *Sorex longirostris*, 3; *Mus musculus*, 2.

White-footed mice were collected at virtually every trap site, even in very swampy areas in which there was standing water. Harvest mice, cotton rats, and meadow mice were found only in old fields where there was grass and broomsedge. Even traps set in wooded areas around the edges of old fields failed to catch these species. Pine mice were found only where there was abundant, somewhat moist, hardwood litter. Golden mice were taken only around honeysuckle vines. The two house mice were caught in an old field near a road house. The short-tailed shrews were almost as ubiquitously distributed as the white-

TABLE 1.—*Comparative blood data for some rodents*

	Red cell count	Hemoglobin gms %	Hematocrit	Mean red cell diameter μ	Body wt. gms.
White-footed mouse	10,800,000	15.25	45.89	6.11	19.3
Stand. dev.	±1,700,000	±1.05	±2.95	±.41	±2.5
Number of animals	22	20	17	13	23
Cotton rat	16,135,000	14.61	47.63	7.58	98.6
Stand. dev.	±1,090,000	±.88	±2.53	±.11	±34.8
Number of animals	17	17	12	8	19
Harvest mouse	9,560,000	15.51	43.57	5.95	9.4
Stand. dev.	±1,130,000	±1.05	±5.12	±.31	±1.7
Number of animals	8	4	7	4	8

footed mice. The three southeastern shrews were caught within a radius of ten yards along a small stream where there was a deep, mixed hardwood litter. This entire trapline was only about 200 yards long. Because of their small size these latter shrews would have been particularly valuable for the problem under investigation, but no others could be taken even though every similar habitat that the author could locate was trapped thoroughly several times. The three that were found died in the traps. The trapline that yielded the southeastern shrews gave in addition: 21 white-footed mice, 7 golden mice, 6 pine mice, and 7 short-tailed shrews during five separate trappings from February 23 to June 23.

One trapline of only eleven traps was set to extend about 100 yards along the bank of New Hope Creek near the site of an old mill. This set yielded nine white-footed mice the first night. A total of 65 trapnights produced 25 white-footed mice; no other species was taken. There was an abundant mixed hardwood litter along the creek.

More cotton rats and white-footed mice were taken than were needed for the problem, and they were frequently released at the traps. It was noticed that those released almost invariably returned to the same trap the following night. The animals were identified by such natural markings as: scars, sores, peculiar pigmentation, etc. Once, while working the trap site where the southeastern shrews were found, two white-footed mice were released. Both returned to their respective traps the following night; whereupon, they were taken out and thrown across the stream. Still they returned, but each time they were thrown a little further across the stream for a total of eight nights. The first few mornings the amount of droppings testified that the mice had spent most of the night in the traps. However, on the last two mornings few droppings were in the traps, suggesting that the mice were entering later. None of these repeat catches was entered into either the number of animals or trapnights.

The data given in Table 1 give some observations on the blood of some of the rodents. These were the only species taken in excess of the numbers needed for the main study.

I express my appreciation to Dr. G. W. Wharton, University of Maryland Department of Zoology, and Dr. F. G. Hall, Department of Physiology and Pharmacology, Duke University, for their advice in the collection and identification of the animals discussed in this paper.—CHARLES W. FOREMAN, *Zoology Department, University of Maryland, School of Pharmacy, Baltimore 1, Maryland.* *Received November 17, 1955.*

A PROTECTIVE DEVICE FOR REDUCING TRAP DISTURBANCE

In recent years a great deal of attention has been given to the design of trapping procedures that conform to some of the assumptions of the statistical techniques often applied to small mammal populations (Stickel, 1946, 1948, 1954; Hayne, 1949; Morris, 1955). Basic to a number of the mathematical models used in the analysis of population data is the assumption of equal probability of capture. Tanaka (1951) and Edwards (1952) have demon-

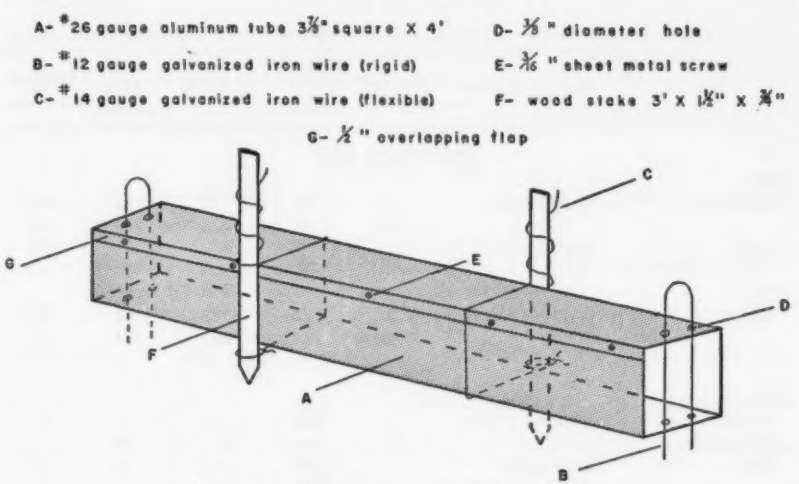


FIG. 1.—Construction diagram of aluminum tubes

strated that this assumption is violated on both the individual and species level. An additional source of error, although obvious, has received little consideration in many population analyses. This is the practical problem of the disturbance of traps which reduces to zero the probability of a capture occurring for any disturbed trap. Admittedly, this probability is of a different nature from those referred to above, since it is independent of the individual or species, but it is of no less importance in studies concerned with the ascertainment of the number of effective traps available on any given trapping night.

That disturbance of traps does occur (in addition to the evidence presented in this paper) and with sufficient frequency to prevent further trapping, has been reported by Brown (1954). He states that while trapping at Silwood Park Field Centre, Berkshire, England, "Squirrels disturbed traps and pulled them apart until trapping of small mammals had to be abandoned." In connection with a study of the habitat relations of the wood mouse (*Peromyscus leucopus noveboracensis*) on the E. S. George Reserve, Livingston Co., Michigan (Brand, 1955), I was confronted with a similar problem of excessive trap disturbance. It was essential in this study that all trapping stations provide equal opportunities for capturing small mammals. The consistent disturbance of many stations during preliminary trapping led to the development of a device to protect the traps from further disturbance. I wish to acknowledge F. C. Evans, L. R. Dice, and I. J. Cantrall for their encouragement and helpful suggestions in the development of this protective device. The funds for the aluminum tubes were supplied by the Institute of Human Biology of the University of Michigan.

After experimenting with several materials and construction plans, it was found that light weight sheet aluminum (#26 gauge) could be folded into rectangular tubes into which traps could easily be placed (Fig. 1). The folding process may be carried out by bending the aluminum around a four foot length of 4 x 4 lumber, creasing the bends with a wood mallet. If a number of tubes are required (more than 100), it is more economical to have them shaped by a precision machine brake available at most sheet metal shops. A one-half inch overlap should be left on one side so that sheet metal screws can be used to fasten the tube securely together. The position and number of holes at the ends of the tube (cf. D of Fig. 1) should be determined by the size of the largest mammal that one wishes to capture. Various combinations of the position and number of these holes will permit the selective trapping

TABLE 1.—*Effectiveness of aluminum tubes in eliminating trap disturbance*

Date	Trapping procedure	Trapping nights*	Minimum dist. (ft.) between stations	No. of trap stations set	No. of trap stations disturbed	Percentage of disturbance
		Before using tubes				
1952						
Summer	Trap lines	1	45	32	32	100
		16	45	315	159	50
Fall	Trap grids	1	60	100	87	87
		8	60	800	390	49
1953						
Spring	Isolated points	1	240	32	22	69
		12	240	385	109	28
		Using tubes				
1953						
Summer, fall, &	Isolated points	1	240	30	2	07
1954 spring		76	240	2040	25	01
Fall	Trap grids	1	120	41	2	05
		4	120	164	5	03

* The first line of numerals after each trapping procedure indicates the maximum disturbance on one night; the second line represents the total disturbance for all trapping by that procedure.

of certain species without varying the size of the trap. Galvanized iron wire in the form of croquet wickets provides an easily inserted and durable block to the entrance of unwanted species. The tubes may be staked to the ground in the manner illustrated in Fig. 1. The wood (or metal) stakes serve as a permanent foundation to which the tubes may be fastened by means of flexible iron wire. The wire is easily loosened to permit the removal of tubes to another trapping station. After a tube has been secured to the ground, set traps may be placed inside by removing the wires from one or both ends and sliding the traps into position. Care must be exercised in placing traps in the center of the tube so that animals cannot reach them through the wires at the end. In this study, small, fiber-board traps were used (Blair, 1941), but many types of standard traps, either live or snap traps, could readily be used in this protective device.

Table 1 presents the amount of trap disturbance that occurred using several different trapping procedures. The first part of the table indicates the excessive amount of disturbance prior to the use of any protective device (trapping periods in the summer and fall of 1952 and the spring of 1953), whereas the second part illustrates the effectiveness of the aluminum tubes in eliminating disturbance. The tubes were put into use in June, 1953, and were used continuously for trapping periods in the summer and fall of 1953 and 1954. For each trapping procedure used (lines, grids, and isolated points), one night has been selected to illustrate the maximum amount of disturbance that occurred. A summary is also given of the amount of disturbance for total trapping for each trapping procedure. The percentage of disturbance is calculated on the basis of the number of trapping stations disturbed rather than on the number of traps disturbed, since the number of traps at each station varied from one to eight for the different procedures used. Stations were considered disturbed if one or more traps were turned over or pulled out of position, or were otherwise incapable of capturing a small mammal when they were checked on the next morning (treadle mechanism jammed, etc.).

In this study the primary source of disturbance seems to have been the larger mammals of the area (raccoons, foxes, and opossums). The aluminum tubes were exceedingly efficient

in eliminating this source of disturbance. The neglible amount of disturbance that occurred when the tubes were in use was probably the result of squirrel and chipmunk activity, since the wires at the end of the tubes were not spaced to prevent animals of this size from entering. In addition to their utility in preventing animal disturbance, the tubes also proved valuable in providing insulation and waterproof covering for the traps.

LITERATURE CITED

BLAIR, W. F. 1941. A simple and effective live trap for small mammals. Jour. Wildlife Mgt., 5: 191–193.

BRAND, R. H. 1955. Abundance and activity of the wood mouse (Peromyscus leucopus noveboracensis) in relation to the character of its habitat. Univ. Michigan Ph.D. Thesis, University Microfilms, Ann Arbor, Michigan.

BROWN, L. E. 1954. Small mammal populations at Silwood Park Field Centre, Berkshire, England. Jour. Mamm., 35: 161–177.

EDWARDS, R. Y. 1952. How efficient are snap-traps in taking small mammals? Jour. Mamm., 33: 497–498.

HAYNE, D. W. 1949. Two methods for estimating population from trapping records. Jour. Mamm., 30: 399–411.

MORRIS, R. F. 1955. Population studies on some small forest mammals in Eastern Canada. Jour. Mamm., 36: 21–35.

STICKEL, L. F. 1946. Experimental analysis of methods for measuring small mammal populations. Jour. Wildlife Mgt., 10: 150–159.

——— 1948. The trap line as a measure of small mammal populations. Jour Wildlife Mgt., 12: 153–161.

——— 1954. A comparison of certain methods of measuring ranges of small mammals. Jour. Mamm., 35: 1–15.

TANAKA, R. 1951. Estimation of vole and mouse populations on Mt. Ishizuchi and on the uplands of Southern Shikoku. Jour. Mamm., 32: 450–458.

RAYMOND H. BRAND, *Westmont College, 955 La Paz Road, Santa Barbara, California.*
Received July 28, 1956.

DISTRIBUTIONAL RECORDS OF THE OPOSSUM IN ONTARIO

Published accounts of the opossum (*Didelphis marsupialis virginiana*) in Ontario leave some doubt concerning its status in this province. The earliest published account of this mammal in Ontario seems to be that contained in THE HAND-BOOK OF TORONTO (Anon. 1858) which indicates that an opossum had been taken locally in the Toronto area. Since no details were given, there remains considerable doubt concerning this record. The only other reference to opossums in this area, known to us, is that of Fleming (1913; see below). In later summaries of the status of this animal in Ontario, Cross and Dymond (1929) report it as formerly having occurred along the north shore of Lake Erie, but that none had been recorded from Ontario in many years; Saunders (1932) referred to the opossum as being of accidental occurrence only; Anderson (1947) notes "a few records from southern Ontario (Essex, Kent, and Middlesex counties), but not known to be definitely resident in Canada at the present time"; Downing (1948) classes it as a rare wanderer to the Lake Erie region; while Miller and Kellogg (1955) follow Anderson's (1947) account almost verbatum.

The following records, arranged in chronological order, provide an interesting history of the occurrence of this mammal in Canada. The number assigned to each locality record corresponds with those of Figure 1.

1. 1858. Toronto, York County. Listed among species said to have been taken locally (Anon. 1858). Listed as only "accidental, one record" by Fleming (1913) although the original notes of this author contain an entry under opossums—"Toronto record—October 1, 1906." (data files R.O.M.Z.P.)

2. 1875. Williams East Township (3 mi. S.E. Ailsa Craig), Middlesex County, Ontario.

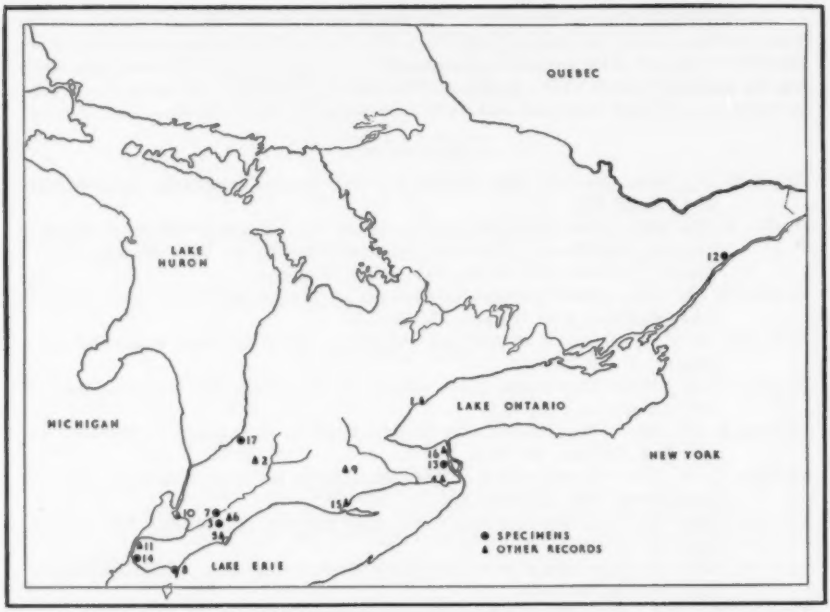


FIG. 1.—Map of southern Ontario showing the localities from which opossums have been recorded. See text for details of each locality record.

An unpublished note from Norman A. Wood of the Museum of the University of Michigan to P. A. Taverner of the National Museum of Canada is in the files of the latter institution (letter from Dr. Austin Cameron) which reports that a live animal, captured locally, was observed by a Mr. Oscar E. Schelt. This report apparently constitutes the basis of Anderson's (1947) Middlesex County record.

3. 1892. Harwick Township (Lot 16, Concession 6), Kent County. Recorded by Smith (1935), this specimen (No. 35-2-6-4) is now in the Royal Ontario Museum of Zoology and Palaeontology (listed below as R.O.M.Z.P.). It was taken alive in mid-February.

4. 1899. Near Port Colborne, Welland County. MacCallum (1901) reports that an opossum (male?) was taken in the middle of January and later mounted for a collection of Mr. Chas. Hays of Port Colborne. Mr. MacCallum also reports that a female with a number of young was killed a few miles west of Port Colborne. Saunders (1932) cites the first specimen only.

5. 1900. Blenheim-Rondeau area, Kent County. A specimen was recorded by MacCallum (1901) for this year, but Saunders (1932) reports on the same specimen indicating that it was taken about February. Saunders also states that "Another was got a week later near the marsh at Rondeau."

6. 1934. Howard Township, Kent County. Recorded by Smith (1935) as a female trapped on or about December 15 on the farm of Mr. Hiram McLarty.

7. 1947. Chatham Township, near Chatham, Kent County. Reported by Cull (1947) and Wood (1948), this specimen is now in the R.O.M.Z.P. collections (no. 16, 949). It was captured alive on February 15, 1947.

8. 1949. Point Pelee, Essex County. Recorded by Zavitz (1953) who found the animal dead and badly decomposed on the shore of Lake Erie on October 3, 1949. The skull only

was saved and deposited in the R.O.M.Z.P. (no. 21580). There is a specimen in the National Museum of Canada, no. 2505, bearing the notation "probably from Essex Co., Ont." This specimen is probably the basis for Anderson's (1947) Essex County record.

9. 1950. Six Nations Reserve, near Ohsweken, Brant County. Shot by Simon Wright at his home on or about March 6, 1950 (data files R.O.M.Z.P.).

10. 1950–51. Walpole Island, Lake St. Clair, Lambton County. Captured alive during either December, 1950, to January, 1951, this animal was sent to the Toronto Zoo (data files R.O.M.Z.P.).

11. 1951. Near Riverside, Essex County. The pelt of an opossum taken by a trapper in a trap set for muskrat was received by Regional Forester R. S. Newman of the Department of Lands and Forests. The final disposition of the pelt is not known. It was supposedly taken in March (data files R.O.M.Z.P.).

12. 1952. Near Morrisburg, Dundas County. A specimen collected by W. B. McConnell in mid-March is now (no. 21, 604 skin and skull) in the R.O.M.Z.P. This apparently constitutes the first record of this species north of the St. Lawrence River east of Lake Ontario.

13. 1952. Stamford Township, Welland County. A specimen, found dead on March 31, is now no. 21738 in the R.O.M.Z.P. collections (skin and skull). Jameson (1943) found no opossums in Welland County but notes that "residents spoke of its presence in former years". Mr. A. R. Muma, Senior Conservation Officer at Chippawa, provides the following information in a personal letter (R.O.M.Z.P. files): "On May 22, 1954, a female opossum, injured by a car on the northern outskirts of Niagara Falls, was taken alive. She was carrying eleven young in her pouch. In captivity she survived as did ten of the young until they escaped about August 1. On September 1 another female was captured alive at the site of the former capture and had survived the winter and still in captivity at the date of writing (April 25, 1955)." Mr. Muma sums up—"There are ten or eleven [recent] records for Welland County. Some were found dead on the highways, two were caught in traps, some were shot and reported later. . . . Most were near the Niagara River, but two were about fifteen miles inland."

14. 1953. Malden Township, Essex County. An opossum is said to have been caught by Mr. Joe Duba on January 19 (data files, R.O.M.Z.P.). Apparently the same animal was shipped alive to Riverdale Zoo in Toronto. (Anon. 1955).

15. 1953. Turkey Point, Norfolk County. A badly decomposed opossum was seen by Mr. George Francis and Mr. James Woodford on the beach along Lake Erie on March 29 (personal communication).

16. 1953. Highway 48, ½ mile south of St. David, Lincoln County. A road-kill picked up about June 18 by Conservation Officer R. Arbuthnot, was forwarded to the R.O.M.Z.P. via the Maple Office of the Department of Lands and Forests. The badly crushed animal was examined and identified by S. C. Downing, and discarded. Two opossums were reported to have been taken in Lincoln County on June 15 and 16 respectively (Anon. 1955). One of these was captured alive but did not survive in captivity. The other is almost certainly the animal referred to above. A. R. Muma's report, referred to above, states, "There are also about six or seven [records of occurrence of the opossum] for Lincoln County."

17. 1955. Goderich Township, Huron County. An opossum was found on a railway right-of-way on March 5 in a near-dead condition by Mr. R. R. Billings. The specimen was forwarded to the Southern Research Station of the Department of Lands and Forests at Maple, where the animal was autopsied (no. 1564) and the skull retained in their reference collection. This apparently constitutes the most northerly record of the opossum in western Ontario. Possibly it had been transported to that point as an undetected stowaway on a train.

Of special interest is the inference from the above records that the opossum has invaded Ontario in a series of "waves." The earliest records may have been purely accidental. A statement that the opossum was "very rare" in "Canada West" (Small, 1866) might be cited as additional evidence of an early invasion although the reference may have been merely a restatement of the earlier record (Anon. 1858). Toward the turn of the century,

1892–1906, at least nine opossums together with an unstated number of young were recorded, after which time none was reported until 1934 when a single animal was recorded. The opossum again disappeared in Ontario until 1947 which seemed to mark the beginning of a stronger invasion with at least twenty-five adults plus a number of young being noted to date. The increased number observed may be a reflection of better organization of an increased number of observers although the opossum seems to have penetrated further northward during the past invasion than the previous one. The appearance of the opossum in Ontario around 1900 seems to correspond to Allen's (1901) report of northward spread in the state of New York. The last invasion seems to have followed, with a few years lag, a reported increase to the immediate south between 1932 and 1939 (Hamilton, 1933; Stoner, 1939). It seems likely that these invasions may be correlated with cyclic shifts in weather conditions. One or more severe winters may, in effect, eradicate resident populations.

A second interesting point is the time of the year when most appearances are discovered: October, 2; December, 1; January, 3; February, 4; March, 6, and only four in the non-winter months (May and June). From examination of Figure 1, it is evident that the majority of the records are clustered about the logical points of entry. Of the specimens found dead on the shore of Lake Erie, it seems possible they may have been carried across the lake after death. It might be inferred therefore that most opossums entering Ontario do so during winter, possibly crossing on ice or ice rafts. While there are numerous ways by which opossums could cross into Ontario, it seems more than a coincidence that most animals discovered were found during the winter months.

The opossum seems to be in the process of becoming well established as a resident of southern Ontario at the present time. It will prove most interesting to follow its fate in the future to determine whether or not it becomes permanently established and increases in numbers with continued range expansion or whether a series of events will again lead to its virtual disappearance in this province with perhaps a reappearance at some future date.

LITERATURE CITED

Allen, J. A. 1901. A preliminary study of the North American opossums of the genus Didelphis. Bul. Am. Mus. Nat. Hist., 14, (11): 149–188.

Anderson, R. M. 1947. Catalogue of Canadian recent mammals. Natl. Mus. Can., Bul. no. 102, biol. ser. no. 31: 1–238.

Anonymous. 1858. The hand-book of Toronto. Lovell and Gibson, Toronto. 272 p.

———. 1955. Annual report of the Minister of Lands and Forests of the Province of Ontario for the fiscal year ending March 31, 1954, sec. 3, Div. Fish and Wildlife: 1–96.

Cross, E. C. and J. R. Dymond. 1929. The mammals of Ontario. Roy. Ont. Mus. Zool. Handbook no. 1. 54 p.

Cull, J. L. 1947. Opossums in Ontario. Rod and Gun in Canada, 49 (5): 24.

Downing, S. C. 1948. A provisional check-list of the mammals of Ontario. Roy. Ont. Mus. Zool. Misc. Pub. no. 2. 11 p.

Fleming, J. H. 1913. Mammals *in* The natural history of the Toronto Region, Ontario, Canada. The Can. Inst.: 206–211.

Hamilton, W. J., Jr. 1933. The northward spread of the opossum in New York. Jour. Mamm., 14: 151–152.

Jameson, E. W. 1943. Notes on the habits and Siphonapterous parasites of the mammals of Welland County, Ontario. Jour. Mamm., 24: 194–197.

MacCallum, G. A. 1901. The opossum in Canada. Forest and Stream, 57 (11): 205.

Miller, G. S., Jr. and R. Kellogg. 1955. List of North American Recent mammals. U. S. Natl. Mus. Bul. 205. 954 p.

Saunders, W. E. 1932. Notes on the mammals of Ontario. Trans. Roy. Can. Inst., 47, pt. 2: 271–309.

Small, H. B. 1866. The Canadian handbook and tourist's guide. Longmoore and Co., Montreal. 196 p.

SMITH, J. H. 1935. The opossum in Kent County, Ontario. Can. Field-Nat., 49: 109.
STONER, D. 1939. Remarks on abundance and range of the opossum. Jour. Mamm., 20: 250–251.
WOOD, A. A. 1948. An opossum in Kent County, Ontario. Can. Field-Nat., 61: 199.
ZAVITZ, C. H. 1953. Dead opossum on Point Pelee, Ontario, shore. Can. Field-Nat., 66: 144–145.

RANDOLPH L. PETERSON AND S. C. DOWNING, *Division of Mammalogy, Royal Ontario Museum of Zoology and Palaeontology, Toronto.* *Received September 22, 1955.*

THE SHREW *SOREX DISPAR* IN VIRGINIA

Knowledge of the distribution of the supposedly rare shrew, *Sorex dispar* Batchelder, in the southern segment of its range has evolved rapidly in recent years. It has been reported from Pennsylvania (Richmond and Grimm, Ecology, 31: 279, 1950; reports of the Pennsylvania Mammal Survey, by various authors, 1949–52), Maryland (Mansueti and Flyger, Jour. Mamm., 33: 250, 1952), West Virginia (Jackson, North Amer. Fauna, 51: 91, 1928; Wilson and Friedel, Proc. West Virginia Acad. Sci., 15: 86, 1942; McKeever, mimeo. report of West Virginia Mammal Survey, 1951), and North Carolina and Tennessee (Conaway and Pfitzer, Jour. Mamm., 33: 107, 1952). In view of the existing information on its distribution in nearby states, it is not surprising that this shrew can now be reported as an addition to the fauna of Virginia.

From September 12–24, 1955, I trapped for *Sorex dispar* near Castle Rock ("Wind Rock" on Pearisburg quadrangle, U. S. G. S. topographic series), NW slope of Big Mountain, elevation 4100 feet, 4.2 miles NNE Mountain Lake, Giles County, Virginia. Big Mountain is a northeast-southwest trending ridge, whose sides slope gently to the southeast and precipitously to the northwest. Sandstone outcrops form a series of low cliffs a few feet below the crest of the mountain on the northwestern slope. Breakdowns on the flanks of the cliffs have created small areas of talus.

The entire mountain is forested. Dominant trees on the upper reaches of the northwestern slope are red oak (*Quercus borealis*) and red maple (*Acer rubrum*) in dryer places; black birch (*Betula lenta*) on talus and other moist spots. Blackberry (*Rubus* sp.), evergreen shield fern (*Dryopteris spinulosa*), and various annuals form a dense ground cover. As a result of a prolonged drouth, the northwestern slope, usually moist and lush, was abnormally dry at the time of this collection. Ferns and annuals were wilted and mostly prostrate.

Most traps were set among rocks, from 6 to 30 inches below the surface, in all instances as deep as possible, and were baited with oatmeal. Traps were left in place an average of five nights before being moved to a new location. In this habitat, trap lines usually produced as many specimens on subsequent nights as on the first. Trap nights totalled 1645.

A specimen of *Sorex dispar*, a non-breeding, immature female (USNM 301770), was secured on September 16 in a trap set about 12 inches below the surface in a patch of talus. Mature black birches shaded the site. Other mammals taken in the same trap line were *Sorex cinereus*, *Sorex fumeus*, *Blarina brevicauda*, *Peromyscus leucopus*, *Peromyscus maniculatus*, *Clethrionomys gapperi*, and *Napaeozapus insignis* (on the surface of talus). *Neotoma magister* and *Spilogale putorius* were trapped on nearby cliffs.

External measurements of the specimen of *Sorex dispar* are: Total length 114 mm., tail vertebrae 53, hind foot 15, and ear from notch 9. The skull was broken by the trap. Cranial measurements, taken as described by Jackson (*loc. cit.*), are: Palatal length 7.2 mm., interorbital breadth 3.4, maxillary breadth 4.5, and maxillary tooth row 6.5.

This specimen and one from Raleigh County, West Virginia (USNM 160787), resemble typical *Sorex dispar*, which presumably occurs from Pennsylvania northward to Maine. However, they verge toward an unnamed form that inhabits the Great Smoky Mountains of North Carolina and Tennessee.—CHARLES O. HANDLEY, JR., *U. S. National Museum, Washington 25, D. C.* *Received November 17, 1955.*

SOREX MERRIAMI AND *MICROTUS MEXICANUS* IN COLORADO

The third specimen of *Sorex merriami* and the first of *Microtus mexicanus* from Colorado have been taken in Mesa Verde National Park by the Park Archaeologist, Mr. Don Watson.

Sorex merriami leucogenys Osgood.—A single specimen in the collection of the Mesa Verde National Park, consisting of skin and skull, was identified by one of us (Rodeck) in a small collection of mammals sent by Mr. Watson to the University of Colorado Museum for identification. The specimens were sent for corroboration to the University of Kansas, Museum of Natural History where Drs. E. R. Hall and J. S. Findley verified the identification of this rare shrew. This shrew was taken in a live trap in the course of intensive trapping to remove small rodents from a plot which was being seeded. No other species of shrew is known to occur in the Park. The nearest record for *Sorex merriami* is Gooseberry Ranger Station, Elk Ridge, 8560 feet, San Juan County, Utah, approximately 80 miles to the west of Mesa Verde (Durrant and Lee, Jour. Mamm., 36: 560, 1955). The first specimens from Colorado, from Larimer and Moffat counties, were reported by Hoffmeister and by Starrett and Starrett in the preceding number of the Journal of Mammalogy (Vol. 37, no. 2).

Microtus mexicanus mogollonensis (Mearns).—A single specimen, skin and uncleaned skull, on deposit in the Denver Museum of Natural History, was examined in connection with a systematic and distributional study of *Microtus montanus* by one of us (Anderson). The skull was subsequently cleaned and more careful comparison proved the specimen to be *Microtus mexicanus*. The identification to subspecies, *mogollonensis*, is tentative and on geographic grounds. This vole was taken at a rock ledge at the head of Spruce Tree Canyon, on March 3, 1941. Two additional specimens have been prepared for the collection of the Park by Mr. Watson who reports that this species was more abundant in 1954 than at any time in the last two decades. These voles were abundant also on Mount Taylor, Valencia County, New Mexico, where 13 were obtained in 65 traps set one night, in September, 1954, by one of us (Anderson). The nearest record to Mesa Verde for this species is Fort Wingate, New Mexico, 120 miles to the south (Bailey, North Amer. Fauna 53: 199, 1931). The desert between Fort Wingate and Mesa Verde is probably not occupied by the Mexican vole which is most common at higher altitudes in grassy parklike stands of yellow pine. *Microtus mexicanus* should be sought in the Chuska Mountains which bridge this distributional gap in part.—Hugo G. Rodeck, *University of Colorado Museum, Boulder, and* Sydney Anderson, *University of Kansas, Museum of Natural History, Lawrence.* *Received September 22, 1955.*

NEW RECORDS OF *SOREX MERRIAMI* FOR EASTERN WASHINGTON

Since the winter of 1952–53 twenty specimens of the Merriam shrew, taken in the eastern part of the state, have been deposited in the Conner Museum at the State College of Washington. Five were caught in snap traps baited with wet oatmeal-peanut butter, two in snap traps baited with wet oatmeal mixed with freshly ground meal worms (*Tenebrio*), and thirteen in sunken cans partly filled with water. All specimens caught in pitfalls were preserved as skeletons.

Jackson (North Amer. Fauna, 51, 1928) recorded a specimen taken at Starbuck, Columbia County, on November 18, 1919, by George G. Cantwell; elevation 645 feet. Since it is indicated that this shrew was taken on top of a "high bunchgrass hill", it is clear that the elevation may be erroneous. Reference to U. S. Geological Survey Map, Starbuck quadrangle, shows that any hills in the area that might be considered high have altitudes of 1,200 to 1,600 feet.

Johnson, *et al.* (Murrelet, 31(3): 39–42, 1950) reported one taken in the Grand Coulee, sixteen miles north of Coulee City, Grant County. James (Jour. Mamm., 34: 121, 1953) recorded one specimen trapped eighteen miles south of Wilbur, Lincoln County, and one seventeen miles east of Ellensburg, Kittitas County. Johnson and Clanton (Murrelet, 35(1): 1–4, 1954) listed forty-six *Sorex merriami* caught in Douglas, Lincoln, Grant, Kittitas, and Yakima counties, without giving specific localities. Nearly all were caught in traps set in *Lagurus* runways in sagebrush-bunchgrass areas.

New locality records.—ASOTIN COUNTY: Pleasant Ridge, one mile southeast of Potter White Hill: two in sunken cans, January–February, 1953 (D. L. Goodwin). Cloverland Grade, about three and one-half miles southwest of Asotin: two in snap traps, October 29, 1953; six in sunken cans, fall and winter 1953–54; one in can, March, 1955 (G. E. Hudson). GARFIELD COUNTY: About eleven miles southeast of Pomeroy on U. S. Highway 410: one in sunken can, winter of 1954–55; one in November, 1955 (G. E. Hudson). LINCOLN COUNTY: Five miles southeast of Creston on U. S. Highway 10A: one on April 5, 1954 (M. Bacon). Fourteen miles northwest of Odessa on State Highway 4B: one on November 6, 1954 (M. Bacon). Five miles south of Wilbur on State Highway 4B: three on October 2, 1954 (M. Bacon). WHITMAN COUNTY: Wawawai Canyon: two in sunken cans about two miles southeast of Wawawai, one in winter, 1953–54; one in February–March 1954 (G. E. Hudson).

Habitat.—Most of the specimens of *Sorex merriami* taken in the state have been captured in what Daubenmire (Ecol. Monog., 22: 301–330, 1952) calls the *Artemisia* semi-desert zone. However, those from the extreme southeastern corner were found in the *Agropyron* grassland zone and on the ecotone between this and the *Festuca* grassland zone. Specimens from Douglas, Grant, Lincoln, Kittitas and Yakima counties have almost without exception been taken in areas dominated by sagebrush (*Artemisia tridentata*) and bunchgrass, mainly *Agropyron spicatum*. One such area near Creston, Lincoln County, was within a quarter of a mile of sparse ponderosa pine timber. In Asotin, Garfield, and Whitman counties this shrew has been taken at only one place where sagebrush occurs, namely, Pleasant Ridge, Asotin County. Specimens from the Cloverland Grade, Asotin County, from Garfield County, and from the Wawawai Grade in Whitman County were caught in areas where the principal vegetation is rabbitbrush, *Chrysothamnus*, and bunchgrass (*Agropyron spicatum*); however, at some sites the following also occur: Idaho fescue (*Festuca idahoensis*), wild rye (*Elymus cinereus*), wild rose (*Rosa*), snowberry (*Symphoricarpos albus*), syringa (*Philadelphus lewisii*), and ocean spray (*Holodiscus discolor*). The Merriam shrew was captured at altitudes ranging from about 1,200 feet on the Cloverland Grade to approximately 3,200 feet on Pleasant Ridge.

Mammals associated with Sorex merriami.—Mammals most commonly associated with the Merriam shrew are *Microtus montanus*, *Peromyscus maniculatus*, *Perognathus parvus*, *Thomomys talpoides* and *Reithrodontomys megalotis*. *Lagurus curtatus* and *Eutamias minimus* were captured on trap lines near Wilbur, Lincoln County, and both of these were reported by Johnson and Clanton (1954). In the southeastern corner of the state *Sorex vagrans* was taken at all sites where *Sorex merriami* was found. In 1953–54 six *Sorex merriami* were caught on the Cloverland Grade and no *Sorex vagrans*; in 1954–55 only two *Sorex merriami* were captured in this area, but six *Sorex vagrans* were taken. On the Wawawai Grade the number of *Sorex vagrans* captured in cans outnumbered *Sorex merriami* by about twenty-five to one. Johnson and Clanton (*loc. cit.*) reported *Sorex vagrans*, *Microtus longicaudus* and *Onychomys leucogaster* as occasional in *Sorex merriami* areas.

Weights and measurements.—Males—Weight (8): 4.2–5.9 gm., mean 4.97. Measurements (10): length 92.5–104 mm., mean 97.74; tail 34.3–40 mm., mean 36.83; hind foot 11–12.3 mm., mean 11.78. Females—Weight (2): 4.9 and 6.8 gm. Measurements (6): length 88–101, mean 95.05; tail 34.5–38, mean 35.93; hind food 11.2–12.3, mean 11.75.

Discussion.—Fifty specimens of *Sorex merriami* had previously been reported from Washington; those listed here bring the total to seventy. Previous records were from six counties; three new county records are Asotin, Garfield, and Whitman. These shrews are widely distributed and apparently locally common in suitable *Artemisia-Agropyron* and *Chrysothamnus-Agropyron* communities in the eastern part of the state. They do not come to bait readily although several have been taken in baited traps. Examination of the stomach contents of six caught in snap traps shows that five had eaten bait. Five were caught in nine hundred trap nights in Lincoln County. However, fifteen hundred trap nights in Asotin, Garfield, and Whitman Counties at sites where this shrew is known to occur yielded only two specimens. Sunken cans partly filled with water seem to be the most effective

method of establishing locality records with a minimum of effort.—George E. Hudson and Marion Bacon, *Department of Zoology and Department of Bacteriology, State College of Washington, Pullman.* *Received December 10, 1955.*

A RECORD OF *MICROSOREX HOYI* FROM KENTUCKY

While examining a series of old specimens found in storage at the University of Kentucky, a specimen of *Microsorex hoyi winnemana* Preble was discovered. The specimen, originally in alcohol, is now completely dried. The label bears the following notation: "Ky., Dec. 30, 1904. *S. hoyi*? Miller".

Presumably, the specimen was collected by Dr. Arthur M. Miller, a member of the staff of the University of Kentucky from 1892 to 1929. According to Dr. William S. Webb, who knew Dr. Miller intimately, the handwriting on the label is that of Dr. Miller. It has been established that Dr. Miller, a geologist, was an able collector, and had more than a passing interest in vertebrate animals, and particularly in shrews.

It is unfortunate that a more accurate record of the locality from whence the specimen came is unobtainable. However, the specimen stands as evidence of the occurrence of the species within the state, although there are apparently no additional records.—Roger W. Barbour, *Department of Zoology, University of Kentucky, Lexington.* *Received October 28, 1955.*

REPRODUCTION OF *TALPA EUROPAEA* IN SUFFOLK

An examination has been made of 567 females out of a total of 1364 moles (*Talpa europaea* L.) taken from 50 miles of river-bank in the Suffolk (England) fenland by a mole-trapper. Table 1 shows the numbers caught each month and their reproductive condition. The pregnant category includes post-implantation stages only as a corpus luteum count was generally impossible owing to poor preservation.

The earliest pregnancy was recorded in March in 1954 and February in 1955, and the latest pregnancies were recorded in June. In both years pregnancies were at a peak in the first half of April. The presence in May and June of four individuals in early stages of pregnancy with enlarged and obviously recently functional mammary glands provides definite evidence of the occurrence of second litters. The proportion of females in this class, however, is small (2.7% of parous females in 1954 and 1.6% in 1955), and the inclusion of those individuals in pro-oestrus and oestrus in the same months only slightly increases the percentages. It is possible that a few second litters were undetected since the mammary glands of individuals in the later stages of a second pregnancy would probably be indistinguishable from those enlarging for the first time. In this species the placentae are not shed at parturition (Vernhout, 1894), so that the absence of large placentae undergoing reabsorption suggests that the litters were conceived at a post-lactation rather than a post-partum oestrus. As second litters appear to occur in such a small proportion of females, their occurrence may have escaped notice in some earlier studies because of the smallness of the samples examined. Four of the females taken during the months July–October were in pro-oestrus or oestrus (Table 1). As it was not possible to determine whether or not they had previously bred, their condition cannot definitely be attributed to a delayed first oestrus, or to a subsequent oestrus interrupting the post-lactation anoestrus. The possibility that the animals were juveniles exhibiting precocious sexual activity can, however, be dismissed, as examination of tooth-wear showed that three of them were at least one year old. (The teeth of the fourth were not preserved.)

The average number of embryos was 3.63 ± 0.17 in 1954 and 3.97 ± 0.18 in 1955 (not a significant difference), giving a mean figure for the two years of 3.82 ± 0.13. The mode was 4 and the range 2–6. Six embryos were found only twice, however, that is, in approximately 2 per cent of pregnancies. Embryos undergoing reabsorption were observed in three animals in 1954 and one animal in 1955, i.e., in approximately 6 per cent of pregnancies. Reabsorbing embryos formed 3 per cent of the total.

Twenty-one females caught in Cheshire during May, 1954, were also examined. The

TABLE 1.—*Numbers and reproductive condition of female Talpa europaea taken in Suffolk in 1954 and 1955*

	Anoestrus	Pro-oestrus	Oestrus	Pregnant	Lactating	Parous	Sex. immature	Total ♀	% Pregnant	% Lactating
1954										
January	19							19	—	—
February	6	11						17	—	—
March	6	32		5				43	11.6	—
April	1	6		12	4			23	52.2	17.4
May		1	7 (3)	10 (2)	54	15	14	101	9.9	53.5
June			2 (1)	2 (1)	5	17	29	55	3.6	9.1
July		1				22		23	—	—
August						36		36	—	—
September						23		23	—	—
October		1	1			69		71	—	—
								411		
1955										
January	25	2						27	—	—
February	2	4		1				7	(14.3)	—
March	1	3		8				12	(66.7)	—
April			1	17	8	3		29	58.6	27.6
May	1	3 (1)	2 (2)	10 (1)	26	11	2	55	18.2	49.0
June			1 (1)	3	2	5	6	17	17.6	11.8
July		1				8		9	—	—
								156		

Parentheses indicate individuals with enlarged mammary glands.

sample had the following composition: Pro-oestrus, 1; oestrus, 0; pregnant, 15; lactating, 1; per cent pregnant, 71.4; per cent lactating, 4.8. The percentage of pregnant animals is obviously higher than in the May sample from Suffolk (Table 1), and a comparison between the two sets of figures suggests that breeding began at least one month later in the more northerly locality.

The data given here agree closely with those reported previously. Adams (1903) stated that the mole has a single litter in the season, and this was confirmed by Matthews (1935). Larkin (1948) found, however, that a small proportion of females came into a second oestrus. In Europe, *Talpa europaea* is said to have one litter only (Kuzyakin 1935, Stein 1950), although the presence in July and August of occasional females in breeding condition suggests that some individuals may in fact produce a second litter. There is evidence that occasionally litters are born even later in the season. Thus Larkin (*loc. cit.*) noted placental sites in the uterus of an animal taken in November, and Stein (*loc. cit.*) caught a very young female in this month. The average number of embryos reported here agrees closely with the figures of Evans (1906) and Larkin (1948), which are 3.86 and 3.80 respectively. The widely-quoted figure of 3.63 obtained by Adams (1903) refers to nestling young. The average number of embryos appears to be larger in Europe.

This work was carried out while in receipt of a grant from the Nature Conservancy.

LITERATURE CITED

ADAMS, L. E. 1903. A contribution to our knowledge of the mole *Talpa europaea*. Mem. Manchr. Lit. Phil. Soc., 47: 1–39.

EVANS, W. 1906. The mammals of the Edinburgh or Forth area. Proc. Roy. Physical Soc. Edinburgh, 16: 387–405.

KUZYAKIN, A. P. 1935. Material on the biology of the mole (*Talpa europaea* L.) of Tula deciduous forest. (In Russian) Bul. Soz. Nat. Moskou (Biol.), 44: 230–239.

LARKIN, P. A. 1948. The ecology of mole (*Talpa europaea*) populations. (D. Phil. Thesis, Bureau of Animal Population, Oxford unpubl.)

MATTHEWS, L. H. 1935. The oestrous cycle and intersexuality in the female mole (*Talpa europaea* Linn.). Proc. Zool. Soc. London, pp. 347–383.

STEIN, G. H. W. 1950. Zur Biologie des Maulwurfs, *Talpa europaea* L. Bonner Zool. Beiträge, 1: 97–116.

VERNHOUT, J. H. 1894. Über die Placenta des Maulwurfs. Anat. Hefte: 1–50.

GILLIAN K. GODFREY, *Zoological Society of London.* *Received November 10, 1955.*

NEW LOCALITY RECORDS FOR TEXAS BATS

Some 2,000 bats have been taken in 1954–55 in connection with an investigation of these animals as possible reservoirs and transmitting agents of rabies virus. Because of the frequency of virus isolations from the Mexican free-tailed bat, *Tadarida mexicana* (Saussure), most of our interest has centered on this species. Fortuitously, most of the large free-tailed bat retreats in Texas are in the central part of the state within reasonable distances of our Austin headquarters.

While collecting bats rather intensively, locality records have been obtained that appear to represent extensions of the known ranges of two species. A female *Dasypterus floridanus* Miller was taken in Austin, Texas (Travis County) from a garage August 1, 1954. This bat has been previously reported from the Gulf Coast (Harris County) on the basis of a single specimen (Taylor and Davis, Texas Game and Fish Comm., Bull. 27, 1947). We also have a specimen from Houston (Harris County) taken from a palm tree, May 28, 1954.

The second species to be dealt with herein is the lappet-chinned bat, *Mormoops megalophylla senicula* Rehn. All of the records of *Mormoops* in Texas probably refer to this subspecies, the type locality of which is Fort Clark, Kinney County, Texas. This bat is recorded in Texas from Brownsville in the Lower Rio Grande Valley by Taylor and Davis (*loc. cit.*). Mohr (Nat. Spel. Soc., Bul. 10, 1948) cites the presence of this bat in Frio Cave, Uvalde County. There is still a good sized colony of an estimated 6,000 specimens in Frio Cave at certain times of the year. We have surveyed most of the other caves in the vicinity and have found *M. megalophylla* in but one. On February 25, 1955, two were taken from Haby Cave, Medina County and another taken on March 10, 1955. This is apparently a new county record. Only a small colony was present in association with several thousand *Myotis velifer incautus* (J. A. Allen).

Our observations of the *M. megalophylla* colony in Frio Cave has indicated the interesting possibility that the cave is utilized by this species chiefly as a winter retreat. The chamber favored by the *Mormoops* is not large, only 10–12 feet high, 30–40 feet wide and about the same length. It is reached by a narrow, low-ceilinged, tortuous passageway and has been called "the warm room" because the temperature and humidity are several degrees higher than in the remainder of the cave. In February and early March, 1955, the colony was at full strength. Toward the end of March and throughout the summer none could be found in this location. September 16, 1955, a dozen or so were found and by November 16, 1955, the colony was approaching its maximum size. We intend to investigate this situation at greater length.

Dr. Frank Blair, University of Texas, Austin, kindly verified the determinations of the *Dasypterus floridanus*, and Dr. W. W. Dalquest, Midwestern University, Wichita Falls, Texas, identified the *Mormoops* to subspecies.—R. B. EADS, G. C. MENZIES AND J. S. WISEMAN, *Texas State Department of Health, Austin.* *Received November 20, 1955.*

SWIMMING ABILITY OF THE LITTLE BROWN BAT

The account by Craft and Dexter in the August 1955 issue of this journal reporting swimming in *Myotis l. lucifugus* (LeConte) brought to mind our own observation of this activity,

10:30 AM (EST) April 24, 1953. While at Lake Musconetcong, Netcong, New Jersey, we observed a lone individual of this taxon flying aimlessly about the shoreline. It alighted once under the eaves of a shed, but our approach caused it to fly off again. Somehow, it fell into the lake about fifteen feet from the shore. The water was choppy, but the bat proceeded to swim directly toward shore. It swam against the side of a rowboat tied at the lakeside and continued attempting to swim forward buffeting the boat repeatedly. It did not attempt to swim around the boat to shore. We rescued it after some minutes and it was still sufficiently energetic to struggle violently and bite one of us.

Under the circumstances, it is likely that this bat was utilizing its ultrafrequency phonoreception capacities while in the water to locate the nearest point of shoreline. The intervention of such a relatively large object as a rowboat in its path coupled with the extreme turbulence of the waves against the bobbing boat apparently rendered it incapable of coping with the situation.—BERNARD C. PATTEN, JR. AND MARIE A. PATTEN, *Fort Detrick, Frederick, Maryland. Received August 20, 1955.*

MYOTIS SUBULATUS LIEBII IN EASTERN NEW YORK

Since the distribution of the least brown bat, *Myotis subulatus liebii*, is poorly known, the following occurrence seems worthy of record.

On January 27, 1955, six specimens of this species were found in an abandoned mine-shaft near Sprakers, Montgomery County, New York. They were found in company with two *Myotis keenii septentrionalis* and one *Eptesicus fuscus fuscus*. One of the six was preserved, and is now in the collection of the New York State College for Teachers, Albany, N. Y.

The mine-shaft is located along a large creek, which passes through a tract of hemlock-beech-hard maple forest. This shaft extends about 90 feet horizontally into the side of a steep hill, and in cold winter weather the temperature falls to nearly freezing throughout its length. It regularly harbors about a dozen bats in winter, but these do not represent a constant population. Bats banded in mid-winter visits to the shaft have invariably been gone at the next visit. The shaft probably serves as a temporary stopping place for small numbers of bats from a larger cave population in the vicinity. The evidence indicates that all three of the species recorded are active, at least occasionally, throughout the winter.—HAROLD SCHWAGER AND ALLEN H. BENTON, *Department of Biology, N. Y. S. College for Teachers, Albany. Received September 30, 1955.*

ADJACENT ROOSTS OF *EPTESICUS* AND *MYOTIS*

Both the big brown bat, *Eptesicus fuscus fuscus*, and the little brown bat, *Myotis lucifugus lucifugus*, have summer roosts in attics and barns in Ohio. The roosts of the two species are widely separated. Even within the same species, banded bats from one roost have not been found at another roost. Over most of the state roosts of the little brown bat are much more freq ently found than those of the big brown bat. However, in the seven county area of southwestern Ohio and northern Kentucky, in the vicinity of Cincinnati, the big brown bat is the common species. Numerous small maternity roosts are found; single specimens are frequently captured in houses and other buildings. But, during the last twenty years, only a single roost of the little brown bats had been discovered; no single specimens have ever been captured or shot or netted. The bats in this roost in Newtown in eastern Hamilton County, [illegible] miles from the nearest known *Eptesicus* roost, were exterminated in 1951.

In a recent survey of bats in the Cincinnati area, a roost of little brown bats was discovered in the attic of a hundred-year-old house in Elizabethtown in western Hamilton County, twenty five miles from the roost exterminated in Newtown. In the barn, fifty yards from the house, was a roost of big brown bats. The collection of August 18, 1955 is summarized as follows:

The total population of *Eptesicus* was estimated at 40, of which 27 were captured. Twelve of these were adult females and five and ten were male and female juveniles, respectively.

For *Myotis*, the total population was estimated at 500, of which 91 were captured. Of these, 64 were adult females, 4 were juvenile males and 23, juvenile females.

The roosts of both species were large and well-established. The owners had observed both since 1937, but the droppings in the attic suggest a much longer tenancy. The population of little brown bats is the largest observed in the state; the population of big brown bats is greater than that found in most roosts. This is the only case that has come to our attention of large maternity roosts of both species in the same territory.—Elizabeth Smith and Woodrow Goodpaster, *Department of Anatomy, University of Cincinnati, Cincinnati, Ohio.* *Received September 2, 1955.*

MIGRATION RECORDS OF THE RED BAT, *LASIURUS BOREALIS*

Sometime during the night of October 18–19, 1955, two male red bats were killed when they struck the 1,472 foot high Empire State Building in New York City, presumably during their migration flight southward. The bats were found on one of the roof set-backs of the building. They were picked up by maintenance men of the building who also gathered 156 dead birds of 18 species that struck the building early on the morning of October 19. The maintenance men claim that the bats struck the building at about 11 o'clock on the night of October 18, when the skies were clear, but that the birds were killed at about 8 o'clock on the morning of October 19, when cloud ceiling heights, according to local weather reports, dropped to about 1,100 feet above ground level.

On the night of October 5–6, 1954, when a similar disaster occurred at the Empire State Building, killing a known number of 123 birds of 28 species, four red bats were also killed. These were given to the American Museum of Natural History and presumably went into their collections.

On September 1, 1955, I caught a live female red bat with my hands that I saw hanging from the branch of a wild black cherry tree in Central Park, New York City. The bat was only about eight feet above the ground, and bore a striking resemblance to a dead brown leaf. It hung from a twig among a cluster of green leaves, and was asleep when I caught it. I examined it for ectoparasites but found none. I returned it to its perch by putting its feet to the twig, which it clutched, and after a momentary shuffling movement of its wings, seemed to go back to sleep. When I came to look for it the next day, it had disappeared.

On September 21, 1955, about fifteen feet from where I caught the red bat on September 1, in Central Park, New York City, I saw a male red bat hanging from a twig of a blue beech tree, *Carpinus caroliniana*. This bat was also about eight feet above the ground. I caught it and examined it for ectoparasites but could find none. I took it to my apartment to keep it overnight but while allowing it to fly about my bedroom in order to study its flight, it flew out of a partly opened window and disappeared. Unfortunately, I had no bands with which to mark these two specimens, but now have some in preparation for other bats that I may capture alive.—John K. Terres, *National Audubon Society, 1130 Fifth Avenue, New York 28, New York.* *Received November 4, 1955.*

OCEANIC RECORDS OF *LASIONYCTERIS NOCTIVAGANS* AND *LASIURUS BOREALIS*

Since the migration habits and routes of tree bats are poorly known it seems worthwhile to report the following observations made aboard the research vessel *Blue Dolphin* while she was engaged in oceanographic research by the Woods Hole Oceanographic Institution in waters off southern New England in the summer of 1953.

On August 19 at 1100 in 39°36′N, 71°03′W (about 95 miles SSE of Montauk Pt., Long I., the nearest land) a male silver-haired bat, *Lasionycteris noctivagans* (Le Conte), was collected from the rigging of the vessel. The bat had circled the ship several times before coming to rest. The junior author climbed after the bat which left the rigging, flew away a few feet, alighted on the author's back and crawled in between his thighs where it was caught with a dip net.

On August 15 hurricane "Barbara" passed through the area with strong SE, then strong

NW winds off southern New England. Weather Bureau North Atlantic charts show light and variable and 5–10 knot NW winds for the area along southern New England and offshore to the point of our observation during August 16–19.

Another lone bat was sighted on August 25 at 1100 in 39°38′N, 70°19′W (about 90 miles SSE of Montauk Pt.) and captured in the rigging after it made a brief flight around the vessel. This was a male red bat, *Lasiurus borealis* (Müller).

During August 22–24 light and variable winds blew over the area between southern New England and our observation point. On August 25 WNW winds of 5–10 knots prevailed. That both bats had come aboard the vessel while in port (August 17; Woods Hole, Mass.) does not seem probable in view of the fact that both animals were first observed flying over the water.

Griffin (Bul. Mus. Comp. Zool., 76: 217–246, 1940) in his studies of New England bats has carefully summarized the coastal and oceanic records of tree bats. He cites seven records for the red and six for the silver-haired bat with two additional accounts in which the bat was not identified. More recently Carter (Jour. Mamm., 31: 349–350, 1950) reported a red bat 65 miles off the southern New England coast. Except for a report by Merriam (Trans. Roy. Soc. Can., Sect. 4: 85–87, 1887) who includes spring records for both species, all observations at sea are for late August or September.

Joseph Chase provided us with the meteorological information.—John Mackiewicz, *Department of Entomology, Cornell University, Ithaca, New York* and Richard H. Backus, *Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.* (*Contribution No. 805 of the Woods Hole Oceanographic Institution*) *Received October 8, 1955.*

DAYTIME ROOST OF THE YELLOW BAT IN VERACRUZ

On July 22, 1955, a field party from the University of Kansas found yellow bats, *Dasypterus intermedius* (H. Allen), concealed among dried corn stalks hanging from the sides of a large, open tobacco shed, one mile southwest of Catemaco, Veracruz. This shed, approximately 60 feet long, 40 feet wide, and 25 feet high, was constructed of vertical poles that supported a corrugated metal roof. The shed was braced on the sides and ends by horizontal poles that were spaced five feet apart. The dried corn stalks were folded over these poles so that the sides of the shed appeared to be thatched. The interior of the shed was not in use.

Dickerman disturbed the bats into flight by agitating the corn stalks with a long pole from the inside of the shed. Baker, South G. Van Hoose, Jr., and others of the field party stood outside the shed and shot some of the bats as they emerged.

Approximately 45 yellow bats were flushed; the bats emerged either as singles or in groups of as many as eight individuals. As bats were dislodged, they dropped from the thatch and dispersed, flying away in an erratic fashion. Most of the bats flew out from the row of corn stalks nearest the roof. Bats were found only on the south and east sides of the shed, even though corn plants were hung in like fashion on all sides. Another shed of similar construction and less than one-half mile away (in the direction of Catemaco) sheltered only five yellow bats. These were found also only on the south and east sides of the shed. No other species of bat was found in these two sheds.

In all, 15 yellow bats (4 females with worn teeth, 6 females with unworn teeth and 5 males with unworn teeth) were collected (Rollin H. Baker nos. 2975–2989) and are preserved in the University of Kansas Museum of Natural History. The four females with worn teeth were lactating. The others were smaller and seemed to be young-of-the-year.—Rollin H. Baker and Robert W. Dickerman, *The Museum, Michigan State University, East Lansing, and Museum of Natural History, University of Minnesota, Minneapolis.* *Received September 23, 1955.*

TRYPANOSOMA VESPERTILIONIS FROM SOME SOUTHERN CALIFORNIA BATS

The presence of *Trypanosoma vespertilionis* in California bats was reported by Dias (Roy. Soc. Trop. Med. and Hyg., 1937) in the pallid bat *Antrozous pallidus pacificus*. Sub-

sequent investigators Wood (Amer. Jour. Hyg., 1941, Jour. Parasit., 1951) have recorded the existence of this trypanosome in additional species of bats predominantly from the southwestern portion of the United States.

During 1950–51 one hundred and forty bats were examined for the presence of this trypanosome. Eight species, embracing three families of Chiroptera, were included in the collections. These animals were taken from various areas within San Diego County, California. Dried blood smears were made, stained with Wright's Stain and later examined microscopically in the laboratory while live drop examinations were made near the field. If these live drop examinations proved negative microscopically, the animal was marked and released.

The author thanks Dr. John L. Mohr of the University of Southern California for his guidance during this study and Mr. E. T. Roche also of the University of Southern California for his assistance during the collections.

The following notes indicate the occurrence of *Trypanosoma vespertilionis* from four of the eight species of Chiroptera examined from San Diego County, California. One crithidia and several developmental forms of this trypanosome are reported.

Pipistrellus hesperus maximus.—One uninfected animal was collected from near Vallecitos in April 1951.

Myotis californicus pallidus.—Six bats were examined from the Old Stage Station at Vallecitos in April 1951. No flagellates were observed.

Macrotus californicus.—Three leaf-nosed bats were examined during April and May of 1951 from the Old Stage Station at Vallecitos. No parasites were observed.

Tadarida mexicana.—Twenty-eight freetails were collected from a large colony under an old bridge near Lakeside during September and October of 1950. No infections were observed. Wood (Pers. Comm., 1951) stated that he has examined numerous bats of this species with negative results and it may be that the freetail does not harbor this trypanosome. This would present a significant situation since both the pallid bat and the freetail have been observed to occupy the same roosts.

Eptesicus fuscus bernardinus.—Nine bats were collected in Lakeside during the months of March, May, and June, 1951. One animal was found infected.

Myotis yumanensis sociabilis.—Seventy-seven bats were collected from a large colony in a flume tunnel above El Capitan Dam. These collections were made in April and May of 1951. One malarial infection (sp. unidentified) and two trypanosomal infections were observed. This is a new host record.

Corynorhinus rafinesquii.—One bat was found infected out of four examined. Two collections were made from a flume tunnel near El Monte Park in March of 1951 and the other two specimens, including the infected animal, from a rock cave near Suncrest. The heart blood of the infected animal yielded a number of thick bodied crithidiomorphic trypanosomes averaging 17.2 μ in total length and 11.2 μ in body width. These forms are intermediate developmental forms of *Trypanosoma vespertilionis* and a new host record for this species.

Antrozous pallidus pacificus.—Twelve bats were collected from in and around Lakeside. Most of the collections were made in the halls and alcoves of the three grammar schools. Six animals were taken during March, April and May 1951. Five infections with *Trypanosoma vespertilionis* were observed. In one case, lung blood from an infected animal yielded many thick bodied trypanosomes and crithidia. This is the first North American report of crithidia for this species.

This species of bat was found to be easily maintained in the laboratory for long periods of time. One animal was utilized for experimental purposes from September, 1950, until May, 1951. Animals so kept, were fed on the larvae of the meal beetle and cockroaches. First feedings were made by holding the food in forceps but in a short time the bats would drop from their roosts to feed readily at a dish of food or drink from a bowl.—ORMOND G. MITCHELL, *University of Southern California, Los Angeles 7, California.* *Received October 11, 1955.*

SUMMER WEIGHTS OF RACCOONS IN NORTHERN MINNESOTA

During the summers of 1948 through 1955, weight data on live-trapped raccoons (*Procyon lotor hirtus* Nelson and Goldman) were obtained at three localities in northern Minnesota. Whitney and Underwood (THE RACCOON, 1952, pp. 1–177) state "The largest coons are still said to come from the north-central states, but as yet we have no authentic weights" (p. 15).

All data presented are live-weights obtained at first capture of the individual. Much of the information was obtained during the period 1950 through 1955 at the Lake Itasca Forestry and Biological Station in Clearwater County. Grants for field studies from the Graduate School of the University of Minnesota made this work possible. Other data are from the Mud Lake National Waterfowl Refuge in Marshall County where Mr. Fred Priewert conducted live trapping studies in 1951 and 1952 and from the Rice Lake National Waterfowl Refuge in Aitkin County where Mr. Lyle J. Schoonover studied raccoons in 1948 and 1949. These two workers were graduate students whose field work was financed, in part, by the U. S. Fish and Wildlife Service.

Data on animals known to be older than juveniles, are presented for the months of June (6 males, 8 females); July (11 males, 8 females); August (9 males, 14 females); and September (1 male, 2 females). It was not possible to separate yearlings from adults as there were insufficient recaptures from year to year to establish points of differentiation. Steuwer, 1953. (Ecol. Mono. 13: 204–257) was apparently also unable to define these criteria.

The average weight of 27 males was 17.5 pounds with a range of 10.3 to 26.0 pounds. Thirty-two females averaged 15.2 pounds and ranged from 11.3 to 21.8 pounds in weight. All of the males weighing 15 pounds and under were taken in June and July as were all females less than 13 pounds in weight—these may be presumed to be yearlings. Comparing these weights with those for adults reported from Michigan for the July-August-September period by Steuwer shows that these Minnesota animals averaged just over three pounds heavier. This is in spite of the fact that, undoubtedly, yearling weights are included here. Six males and four females were heavier than the largest animal of each sex reported by Steuwer.

The weights of juveniles for July and August also appeared to be greater than the average monthly raccoon weights as reported by Steuwer in Figure 17. Nineteen males taken in July averaged 4.5 pounds while Steuwer indicates an average of about four pounds. Eighteen males taken in August averaged 6.5 pounds as against less than five pounds. Fifteen July caught females averaged 4.4 pounds and three August caught females averaged 6.0 pounds. These are also considerably heavier than reported by Steuwer.

A striking series of juvenile weights was obtained by Priewert at Mud Lake. A male weighing 6.0 pounds on July 26, 1951, had increased in weight to 12.5 pounds by September 10, 14.2 pounds by September 26, and 15.6 pounds by October 5. These last three weights are comparable to the 14.6 pounds reported as average for October-November and December yearlings (Table 3) by Steuwer. A female weighing 4.8 pounds on July 20 had reached 10.4 pounds by September 11 and 12.0 pounds by September 27.

In summary, average weights of raccoon obtained during the summer months over a period of eight years in three northern Minnesota localities for twenty-seven males, thirty-two females, and fifty-five juveniles, clearly indicate that animals from this area are exceptionally heavy when compared to data from Michigan.—WILLIAM H. MARSHALL, *University of Minnesota, St. Paul 1, Minnesota.* (*Paper No. 3400 Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota.*) *Received September 9, 1955.*

AN EARLY RECORD OF THE WOLVERINE IN WESTERN NEBRASKA

It is unfortunate for present-day mammalogists that the first explorers of the American wilderness were more interested in survival than in natural science. Only on rare occasions did frontier visitors record observations that today prove of reliable assistance in ascertaining early distribution of American wildlife. One such visitor was Alfred Jacob Miller, an eastern painter who accompanied British adventurer Captain William Drummond

Stewart to the fur trappers' annual summer rendezvous in present western Wyoming in 1837. Although no naturalist, Miller painted and described several mammals, including elk, antelope, bison, mountain sheep, cougar, grizzly bear, and prairie dogs. His most valuable record, however, was that of a wolverine near Chimney Rock in western Nebraska.

In a notation appended to his sketch of Chimney Rock, Miller (THE WEST OF ALFRED JACOB MILLER, Oklahoma University Press: 54, 1951) wrote: "We had here a sight of an animal that is very rarely seen, and said by the trappers to be invulnerable to powder and ball. This was the 'Carcagiou.' It was about the size of a large dog, dark brown, almost approaching black in color, and body very long.

"Trappers tell most incredible stories of its ferocity and believe it to be a cross between the bear and the wolf. They secure their prey by lying concealed in a tree or clump of bushes until a deer or antelope passes beneath—when they spring upon the animal's back, and holding on with their sharp claws soon bring him to the ground."

There are few authentic records of the wolverine for Nebraska and, indeed, many mammalogists have considered Nebraska as beyond the former range of the species. However, according to Swenk (Publ. Nebraska Acad. Sci. 8(3): 128, 1907), wolverines were occasionally encountered in central and western Nebraska as recently as 1880, with several records from the northwestern Pine Ridge country. One specimen, preserved at the University of Nebraska, was collected in Scotts Bluff County in late 1887.

Miller's record near Chimney Rock in the summer of 1837 would have been in the present county of either Scotts Bluff or Morrill. The terrain here along the south side of the North Platte River is rugged, with many bluffs and interspersed ravines dotted with pines and brush, probably suitable but not optimum habitat for wolverines during Miller's day. It might well be that careful scrutiny of other early journals chronicling journeys on the Oregon Trail would reveal more records of the wolverine for this peripheral area.—RICHARD G. BEIDLEMAN, *Zoology Department, Colorado A & M College, Fort Collins (Current address: Univ. Colorado, Boulder.)* *Received October 1, 1955.*

PITUITARY REMOVAL IN *MICROTUS* WITH PRESERVATION OF SKULL

In the course of current work involving a comparative study of several species of *Microtus* it has become evident that pure gross morphology needs to be augmented by, among other things, an exhaustive study of the histochemistry of the cells of the several organs of the animals concerned. One of the key organs that should be studied is the pituitary and this has been so ever since the classic work of P. E. Smith (Jour. Amer. Med. Assoc., 88: 158, 1927). Smith's method of hypophysectomy, while the accepted method in conducting endocrinological experiments with living material, is not suitable for removal of the gland intact for further study. The methods applied on autopsy of experimental laboratory animals for removal of the pituitary where skull measurements are not considered make the skull useless from a mammalogist's point of view.

A method was devised to remove part of the calvarium by making a small transverse cut dorsally behind the orbits with a small, very thin grinding wheel attached to a dentist drill. Two longitudinal cuts are then carried posteriorly to the border of the foramen magnum and the loose bone is then removed in one piece. A pair of fine, sharp scissors can be used in place of the drill with the longitudinal cuts going anteriorly from the foramen magnum. The results, however, will not be quite as satisfactory. This leaves the remainder of the skull intact for the standard measurements that are an important part of taxonomic investigations.

The brain is scooped out of the brain case while the pituitary remains in the sella turcica, held in place by the diaphragma sellae. This immediate area must be treated at once with a drop or so of a hardening fixative such as Bouin's or formalin. After hardening for a short time the diaphragma may be picked carefully away with a sharp needle and the gland transferred to a vial of fixative to await further treatments. The small amount of fixative in the skull, if carefully applied, will not poison the soft tissues of the outside of the skull and so dermestid beetles may be employed for final cleaning and allow the skull to be used for such measurements as the investigator may be desirous of taking.

This method should be used only with freshly killed material inasmuch as post mortem changes begin directly upon death and after a few hours render most tissues unusable for many delicate histochemical procedures. Specimens stored in a freezer directly after death will, when thawed, often have the pituitary pulled away from the sella turcica and are lost in the soft brain tissue as the brain is being removed.—Jay Stuart Haft, *Biology Department, Boston University, Boston 15, Massachusetts.* *Received December 19, 1955.*

REARING OF LEMMINGS AT FORT CHURCHILL, MANITOBA

In the summer of 1950, a lemming colony was started from 60 *Dicrostonyx g. groenlandicus* (Anderson 1946) from Southampton Island, N.W.T. and *Dicrostonyx groenlandicus richardsoni* (Anderson 1946) from Churchill, Manitoba, vicinity. The early days of the colony were described by Arsenault and Barlow (Defence Research Northern Laboratories, Technical Paper No. 4, Defence Research Board, Canada). The emphasis was, in this report, on the occurrence of a spontaneous condition diagnosed, on the basis of polydipsia, bulimia, polyuria and glucosuria as diabetes mellitus. This disease was responsible, according to these authors, for 15 per cent mortality in 1950–1951 and 5 per cent for 1951–1952. This note describes observations, method of rearing and longevity of DRNL colony.

The size of the colony was about 200 in early 1952 and 400 in early 1953. Between 1953 and 1954 few youngsters were kept, and a large number of adults were sent to variou Universities. Ten of these animals were sent as far as England without loss during the air trip.

Rearing conditions.—The animals were always kept in the same room which had a large window on its North side. Although no artificial light was allowed in the room, no attempt was made to divert the daylight. The absence of noise in the animal colony and the regular schedule adapted by the animal keeper were contributing factors in minimizing the disturbance of the colony. The temperature of the room was kept between 35–45°F in the winter and 45–65°F during the summer.

Feeding.—The diabetes observed in 1950–1952 occurred almost exclusively in the winter The rolled oats, which contain 68 per cent carbohydrates, was eaten in larger quantities in the winter. An attempt was made then to reduce the carbohydrate intake by replacing the rolled oats with pellets. This change completely eliminated the diabetic condition and no evidence of this disease has been observed during the last two years. In addition to pellets and water, fed *ad libitum*, each lemming was given approximately 15 grams of carrots and 20 grams of cabbage each day.

Longevity.—Although it was not always possible to estimate the life span of these animals because of the large turnover, we have a record of forty-one animals born in 1951 and kept in our colony until they died. The mean longevity was 694 days (S.D. 231 days). The longest life span on record is 3 years and 3½ months.

Breeding.—Non-absorbent cotton was always available as nesting material, and breeding was more successful in the summer than in the winter. The average size of the litter was between three and four; the largest obtained was seven. The youngsters, who were not disturbed for about two weeks, very seldom died. The best mating age was between four and eight months. Approximately 50 per cent changed their coats in the winter. It seemed to us, although a more detailed study would have to be made, that the subspecies *groenlandicus* molted in greater numbers.

Occurrence in the field.—Mr. T. P. Copps from our Laboratory has been trapping lemmings in the Fort Churchill area since 1949. Although no survey was made, his observations based on many field trips are recorded in Table 1. Observations for the next few years should define the limits of the lemming cycle in Fort Churchill. Data on fox and wolves and avian predators also are being collected and will be published at a later date.

Summary and conclusions.—The average life span of our lemming colony was approximately six times higher than that reported recently by Manning (Arctic 7: 36, 1954); 661 as compared to 105 days. The greater longevity we obtained is probably a result of combined optimal conditions such as temperature, light, and feeding. It is felt however that the temperature is the most important factor in this respect. These optimal conditions are: for temperature, 35–45°F in the winter, and 45–65°F in the summer; for light, those prevail-

TABLE 1.—*Occurrence of lemmings in the Fort Churchill Area between 1948 and 1955*

Year	Population density (arbitrary scale)	Remarks
1949	6	Shipped large number to NRC.
1950	4	Definitely on the decrease. Start of DRNL colony.
1951	1	Lemmings for our colony had to be obtained from Coral Harbour.
1952	2	
1953	4	Definitely on the increase.
1954	5	Not quite as many as 1949.
1955	2	Significantly less than last year.

ing in the vicinity of lemming habitats, with nesting material always available; for feeding, pellets and vegetables. The favourable results obtained are probably explained by the fact that the temperature in the summer and the light in the summer and winter, are very similar in our animal colony to those of the natural lemming habitat. Finally, observations on the population-density fluctuation are given.

Acknowledgments.—The author is most thankful to the animal keeper, Mr. R. Blair, for his devoted and constant interest in our animal colony, to Mr. T. P. Copps, for making available to us data on field occurrence of lemmings in the last six summers, and to the Defence Research Board for permission to publish this article.—J. S. LE BLANC, *Defence Research Northern Laboratory, Fort Churchill, Manitoba.* (*Defence Research Northern Laboratories Technical Note 36/55*) *Present address: Army Chemical Medical Center, Maryland. Received September 20, 1955.*

THE YOUNG OF *NEOFIBER ALLENI*

The round-tailed muskrat, *Neofiber alleni*, is a common microtine of Florida. While reasonably well known to mammalogists and some local residents of the area in which it occurs, the biology of this small counterpart of the muskrat is not well known.

On May 15, 1951 three *Neofiber* (an adult female and two young males) were received from William Hegener of Sarasota, Florida. The animals were taken near Ocala, Florida and may be referred to *Neofiber alleni nigrescens*. The animals were housed in 25 x 36 inch cages in shaded outdoor inclosures. A nest box 8 x 11 inches, with fine wood chips for bedding, was provided the animals. They were given a plentiful supply of carrots, miscellaneous greens, melon rinds, sweet potatoes, oat flakes, and rabbit pellets. All foods were accepted. Water was available at all times; the necessity of frequent water changes is evident in many captive wild rodents who use the water supply for defecation.

The young males (initial weight 76 and 82 gm.), grew rapidly, approximating 270 gm. by mid-August. One of the males was placed with the female on October 11, 1951. Other than a minor skirmish, the large female appeared to accept the young male. They shared the same nest box. An attempted copulation was observed on November 3, several days after the pair had been placed in a greenhouse. Temperature in the greenhouse approximated 20°F. above the average temperature of Ithaca (27°F.) at this time. The male was removed on November 21, 1951.

The nest box of the female was examined on alternate days following the removal of the male. On December 20, 1951, three new-born young (two had suckled) were removed from the nest litter. All were dead. The young were presumed to be not more than a day old, probably less. The three young totalled 21.6 gm., an average of 7.2 gm. each. Measurements of the three average: Total length, 82 mm.; tail, 16, and hind foot, 9. As with most young of microtine rodents (at least those that have been examined at birth), the young were blind, with wrinkled skin, and almost destitute of hair. A few mystacial vibrissae measured 2–3.5 mm. long.

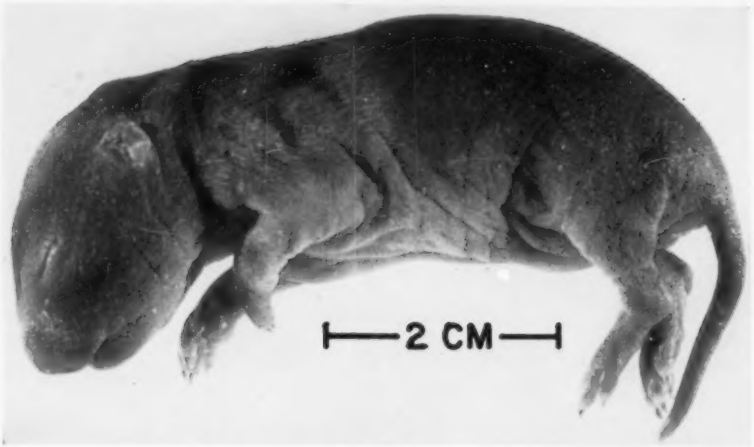


PLATE I

Young of *Neofiber alleni nigrescens* at estimated age of 5–6 days

A gravid female received from Mr. Hegener produced three young during the night of November 19–20, 1951. This animal was placed in the greenhouse and examined every other day. Lest she be unduly disturbed, no effort was made to remove her from the next box. I judged the age of the young to be approximately 5–6 days when examined (Pl. I). The three young, two females and a male, averaged 13.7 gm. (13.4–14.3) and have identical measurements, i.e., t.l. 97, t. 23, h.f. 14 mm. These young have a prominent coating of hair on the dorsum, the ear has unfolded but the eyes are closed. In the young females, the teats are evident, indicating four in the post abdominal and inguinal region; a pectoral pair, that may be functional in time, is suggested only by a slight depression of the region.

Harper (Proc. Boston Soc. Nat. Hist., 38(7), 1927) has recorded scantily haired young with unhealed navels, taken from a nest on January 5, 1917, in the Okefinokee Swamp of southeastern Georgia. This suggests that breeding may occupy the entire year. Elliott (Field Columbian Mus. Pub. 58, Zool. Ser. 3, 1901) records two-week-old young on February 22.—W. J. Hamilton, Jr., *Cornell University, Ithaca, New York. Received September 8, 1955.*

NOTES ON REPRODUCTION IN THE KANGAROO RAT, *DIPODOMYS*

During a preliminary study of the incompletely understood reproductive anatomy and physiology of the kangaroo rat (*Dipodomys*), observations were made that do not conform to statements in a recent paper by Fitch (Jour. Mamm., 29: 5–35, 1948). This author states that non-breeding females of *D. heermanni* have an imperforate and regressed vaginal orifice, while in "apparently" estrous animals the vaginal orifice is open, and its lips are greatly enlarged and thickened. These conclusions resulted from observations of external genitalia only. However, I believe that the situation is more complex than this statement indicates, at least for the species *D. ordii*.

My view is based on observations of 33 female kangaroo rats (*Dipodomys ordii*) captured between February 10 and July 8, 1955 in southwestern Idaho and eastern Oregon. Post-mortem examinations of the reproductive tracts of all animals were performed, either at time of capture or after different periods of captivity. These examinations showed that all pregnant (5) and very recently post-ovulatory females (2, fresh corpora lutea were demonstrated in histological sections of the ovaries) had vaginal orifices that were in a regressed

PLATE I

LEFT: Vaginal orifice of early pregnant female.
RIGHT: Vaginal orifice of sexually inactive female.

condition (Pl. I), whereas in females showing slight sexual activity the opening had tremendously swollen lips, measuring about 1 cm. in diameter (Pl. I). Preovulatory females with some development of the uterus had vaginal orifices that were intermediate between those of pregnant and anestrous individuals. In general, the size of the vaginal orifice was inversely proportional to the development of the internal reproductive organs. Exceptions were noted in young prepubertal females about two-thirds grown, as judged by weight. Although all were sexually inactive, some had regressed vaginal orifices while others were swollen.

That the condition of the vaginal orifice in adult females is under the influence of reproductive hormones was demonstrated by injecting estrogen into an isolated adult female. This individual had exhibited greatly swollen vaginal lips for several weeks when .2 mg. of estrogen (estradiol diluted with sesame oil) were administered intramuscularly. Two more injections were given during the next seven days, and one week after the first injection the lips had completely regressed. Twelve days after the last injection the vaginal orifice was again swollen.

About ten weeks following the above experiment the same female was noted to again have a regressed vaginal orifice, although she had been isolated and untreated since the injections. Because this observation indicated sexual activity, the animal was killed. Fresh corpora lutea were demonstrated in histological preparations of the ovaries proving that the regressed vaginal orifice is correlated with ovarian activity. This event also indicated that *Dipodomys* is a spontaneous ovulator.

Although several adult females were maintained in captivity only the above individual was proven to have ovulated. Duke (Jour. Mamm., 25: 155–160, 1944) reported no ovulation in six captive females except in one specimen that had undoubtedly ovulated prior to capture.

The above evidence, therefore, suggests that ovarian hormones promote atrophy of the vaginal orifice in adult *Dipodomys* instead of hypertrophy as in most rodents. Further investigations into this and other aspects of *Dipodomys* reproduction are in progress.

I thank Professor H. M. Tucker of the College of Idaho for invaluable assistance during this study, and Messrs. D. Reed, D. E. Vassar, M. G. Vale, D. R. Heithecker, and G. H. Elfers for capturing the specimens.—E. W. PFEIFFER, *Department of Biology, College of Idaho, Caldwell, Idaho. (Present address: Dept. of Zoology, Utah State Agricultural College, Logan, Utah.)* *Received September 29, 1955.*

OCCURRENCE OF *PEROGNATHUS FASCIATUS* IN UTAH

It has been pointed out by Durrant (Univ. of Kansas Publications, Mus. of Nat. Hist., 6: 489, 1952) that the mammalian fauna of northeastern Utah is related in several respects to that of the Great Plains. Further support is given to this concept by the recent discovery of *Perognathus fasciatus callistus* in parts of Daggett and Uintah counties.

Perognathus fasciatus Wied-Neuwied was described from North Dakota in 1839 and subsequently several subspecies have been named. The species has been known from southwestern Wyoming and northwestern Colorado for many years under the name *Perognathus callistus*. However, Jones (Univ. of Kansas Publications, Mus. of Nat. Hist., 5: 515–526, 1953) has reduced *callistus* to subspecific rank under the species *fasciatus*.

During the course of field work conducted in 1953 and 1954 four specimens of *P. f. callistus* were taken 15 miles north of Bonanza, Uintah County (El. 6100 ft.) and five were collected at Bridgeport (El. 5600 ft.) Daggett County. Both localities lie east of the Green River. The extent of southward distribution in Utah is not known but it is interesting to note that White River, running westward into Utah from Colorado may divide the ranges of *Perognathus apache* to the south and *P. fasciatus* to the north. In our collections we found only *apache* at Rainbow, a few miles south of White River and only *fasciatus* a few miles north of this stream. However, neither species was common in either locality and more extensive field work will be necessary to determine the effectiveness of White River as a barrier to *Perognathus*.

E. Raymond Hall and Sydney Anderson, who kindly compared our specimens with those in the Kansas Museum of Natural History state that our material is close in measurements to their specimens from Sweetwater County, Wyoming. However, we found our specimens to measure distinctly larger both in body and cranial dimensions than a few topotypes loaned to us by the U. S. National Museum and a small series of individuals from Moffat County, Colorado that the Colorado Museum kindly permitted us to examine. Body measurements of six adult specimens from Uintah and Daggett Counties averaged total length 145, tail 67, foot 19.

Cranial measurements of our specimens from Utah, when compared with those published by Jones (1953, *loc. cit.*) from Sweetwater County, Wyoming. showed slightly larger averages in eight out of nine categories.

Specimens of *Perognathus fasciatus* were taken by us on sandy soil or sand mixed with fine gravel where the predominant vegetation was sagebrush (*Artemisia tridentata*), shadscale (*Atriplex*) and *Tetradymia*. Their habitat was shared by such rodents as *Peromyscus maniculatus*, *Onychomys leucogaster*, *Dipodomys ordii*, and *Reithrodontomys megalotis*. No other species of *Perognathus* was found to associate with them.—C. Lynn Hayward and Merlin L. Killpack, *Department of Zoology, Brigham Young University, Provo, Utah. Received November 18, 1955.*

PELAGE COLOR CHANGES IN *PEROGNATHUS LONGIMEMBRIS*

On October 15, 1950, Mr. Loraine Woodbury captured a specimen of *Perognathus longimembris* in a desert area known as Cedar Valley which lies to the west of Utah Lake in Utah County, Utah. The animal was caught by the tail in a snap trap and was brought into the laboratory alive. Strikingly contrary to the normal color of this species, which is predominantly buff overlaid with brown or black dorsally, the animal mentioned above was pure white except for a grayish mustache and a faint tinge of buffy along the sides. The eyes were black. The specimen was placed in a semi-dark cage made of wood with a screen top and was given oatmeal and water.

A few days passed with no noticeable change in the pelage color although no one was looking for such a change. The animal was cared for on the morning of October 18 and the attendant did not notice any departure from the white pelage condition, although it is entirely possible that some variation might have gone unnoticed. However, on the following morning (October 19) a most remarkable change had taken place. The entire back, from near the tip of the nose to the base of the tail had changed to a ground color of light gray

with a darker mid-dorsal line. There were distinct spots of buffy posterior to the ears and a spot of brownish buff between the ears. There were also two irregular brownish buff spots more posteriorly on the back, and the sides of the animal were distinctly washed with buffy.

The color continued to change through the next few days, and, within a week after capture, the animal had practically attained normal coloration. Possibly the change in physical environment and diet was responsible for an unusually rapid pelage change, but the events were so unexpected and rapid that we were unable to make an adequate study. Shortly afterward the animal died and unfortunately was too badly spoiled, when found, to be saved as a specimen.

In a rather large series of specimens of *Perognathus longimembris* from the Great Basin we have noted that irregular white spotting is not uncommon. Durrant (Univ. of Kansas Publications, Mus. Nat. Hist., 6: 237, 1952) also describes a white-spotted condition in specimens taken by him in the Great Basin. However, the extensive lack of pigmentation and the rapid change noted above seems to be of unusual interest.—C. Lynn Hayward, *Department of Zoology, Brigham Young University, Provo, Utah. Received December 6, 1955.*

UNUSUAL SEX BEHAVIOR OF A MALE PORCUPINE, *ERETHIZON DORSATUM EPIXANTHUM*

A large porcupine (*Erethizon dorsatum epixanthum*) had been captured in the middle of June, 1955, and in his 1½ months in captivity had become relatively tame. He weighed approximately 35 pounds. In the last week of July, 1955, a young female was captured that weighed approximately 10 to 15 pounds.

The male porcupine was removed from his cage by inducement of a piece of dried French toast and taken to the far corner of the building where he remained eating the toast. This was ordinarily done every day so I could clean his cage. The female was then placed in his cage and I waited for the male porcupine to finish his toast so he could be returned to his cage where a pan of fresh food would be waiting. This procedure of cleaning the cage and placing of fresh food in his cage at this time had been performed for 1½ months and he had grown quite accustomed to it. As far as I was able to determine he had no idea the young female had been placed in his cage.

As soon as the male porcupine had gone through his cage door he immediately became aware of the female and raised himself upon his hind legs, his penis being fully erect, and sprayed the female with urine. This thoroughly frightened the young female and she hurried to a corner of the cage where she hid her head between her front legs. The male followed her, trying to smell her genital organs, but the female slapped him in the face with her tail. The male showed no signs of noticing the quills and it wasn't until about an hour later that he began the tedious task of removing the quills. The female then hurried over to the next corner of the cage where the male again approached on his hind legs and tried to mount the female by shoving her tail aside. This continued for ten to fifteen minutes in which time the female continued to refuse the male. Finally the male climbed a limb to the top of the cage and remained there and the female hid in a darker part of the cage.

The female was at this time removed from the cage and because of conditions beyond my control I was unable to continue these observations.

The important point was that the male porcupine had had no contact with this female or any other porcupine for at least 1½ months, yet I feel certain that had the female been in her small period of heat, immediate copulation would have taken place.

This important point differs from the observations of Shadle (Jour. Wildlife Mgt., 10: 159–162, 1946) who stated that "preliminary association with the females seems necessary for the male" in relationship to copulation. In Shadles studies, however, two elements were different than from mine (1) his porcupines were from New York State, *Erethizon d. dorsatum*, while mine were obtained in the California Sierras, *Erethizon d. epixanthum*, and (2) Shadle's porcupines were caged porcupines which had been in his laboratory a number of years, while mine were both relatively wild porcupines, the male in captivity 1½ months and the female just a few hours.

An incident with activity similar to the actions of my porcupine was reported by Taylor (Univ. of Arizona Bul., 6: 111, 1935).

There is one other observation that seems to be different from the reported behavior of a male porcupine. There seemed to be no signs of any presexual urge on the part of the male. Shadle, Smelzer, and Metz (Jour. Mamm., 27: 116–121, 1946) state that more or less of a sexual urge was noted throughout the year and that the male showed signs of sexual urge by vocalizing, rubbing of noses, straddling sticks, etc.

In the 1½ months my porcupine was under observation no presexual urge was witnessed. This may be due to the fact that the male porcupine had had no contact with any porcupine in the 1½ months, which would not be the case in the wild, as many authors have commented on the fact that often adult porcupines, presumably male and female, are seen together in the fall. Taylor (*loc. cit.*) remarks of this and I have also seen this occur a number of times in my studies.

To what extent the presexual urge is demonstrated by the male in the wild has not been reported. This is also true of the actual copulation in the wild.

From this study it does seem likely that there may be some definite variation between the presexual behavior of a caged and wild male porcupine. It must be noted, however, that Shadle and his associates in no way inferred that their observation on the sexual behavior of the caged porcupine was in any way the behavior of a wild porcupine.

Although these observations may not apply to the porcupines as a group it does show that more studies are needed on the presexual and mating behavior of the male porcupine while in a wild or semi-wild state.—JEFF RICHARD SPALSBURY, *Wildlife & Reptile Research Institute, (Temporary Address) 13116 Franklin Ave., Mt. View, California.* *Received November 25, 1955.*

EXTRA TEETH IN A HARE

Among dental anomalies in the leporids, malformation of the incisors has been mentioned in the literature relatively often (Christiansen, Skand. Vet. Tidskr., 34: 449–466, 1944, abstract by J. Egehøj in Biol. Abst., 20: 156, abstract no. 1284, 1946; Gregory, Jour. Mamm., 34: 393–394, 1953; McIntosh, Trans. Roy. Soc. Edinb., 56: 333–407, 1930), but the reported occurrence of extra teeth is less common. Darwin (THE VARIATION OF ANIMALS AND PLANTS UNDER DOMESTICATION. Vol. 1: 150, 1868) reported the case of a rabbit of the domestic lop-eared variety in which one extra cheek tooth was present "on each side of the upper jaw between the molars and premolars; but these two teeth did not correspond in size." Some other instances of extra teeth, either incisors or cheek-teeth, have been recorded (Major, Proc. Zool. Soc. London, 1: 416–417, 1904). To these reports, I add an instance of extra cheek-teeth in a wild hare, *Lepus*.

The skull of an adult leporid, No. Zool. 641, without data, has extra upper cheek teeth. Based on comparisons with identified specimens, the skull is probably of the genus *Lepus*, seemingly species *Lepus californicus*. In addition to the normal three premolars and three molars in each maxillary, one extra tooth is present on each side at the anterior end of the tooth-row.

In the right maxillary the extra tooth is present anterior to, and fitting closely against, P^3. The occlusal surface of this small tooth (transverse, 1.6 mm.; anteroposterior, 1.0 mm.) is oblong with rounded corners, enamel is reduced on the posterior surface, and the rootless shaft is almost straight. The alveolus is separated from that of P^3 by a bony partition, and the shaft of the tooth extends into a bony maxillary tuberosity which is approximately half the depth of that enclosing P^3. Occlusal pattern, size, and position of P^3 do not seem to be altered from the normal condition by the presence of the extra tooth. In the left maxillary the extra tooth is different from that of the right side. This tooth is anteroexternal to P^3 and the latter tooth is displaced medially from its position in a normal dentition. The extra tooth is concave externally to approximately the same extent as are the normal cheek-teeth, and its occlusal surface (transverse, 1.9 mm.; anteroposterior, 1.8 mm.) has two shallow anterior enamel reëntrants. Wear has produced a condition in which the extra

tooth and P^2 together form an occlusal surface similar to that of one normal cheek-tooth. Enamel is reduced externally and posteriorly on the extra tooth. Occlusal wear with the mandibular teeth has produced a transverse groove in the surface of the extra tooth which is a continuation of a groove present on P^2. No bony partition within the alveolus separates the extra tooth from P^2. The proximal part of the shaft of the extra tooth, however, arises from a tuberosity which is shorter than, and anteroexternal to, that of P^2. The pattern of left P^2 is normal, but the tooth is slightly smaller transversely than the right P^2.

The presence of these extra teeth seemingly did not affect this animal adversely, for the skull otherwise appears to be normal and wear on the teeth indicates that effective occlusion approached the normal condition. The extra right tooth is different from the more posterior cheek-teeth in most features. The left extra tooth, however, has a pattern reminiscent of P^2, and its alveolar position indicates a relationship to that tooth. Although there is no direct evidence regarding the cause of these additional teeth, a single mutational or developmental factor could be basically responsible for the extra teeth of both sides. Following this, canalization of later development in diverse directions could result in the different appearance of the extra teeth. However, different factors acting on each side could also produce these results, although this seems less probable to me.

The leporids have been characterized since the late Eocene, which is the time of their first known appearance in the fossil record, by the presence of three premolars, P^2, P^3, and P^4, in each maxillary, and there is no evidence from Eocene, Oligocene, or later leporids that the first premolar was present during any leporid stage of evolution. I interpret this appearance of extra teeth as an abnormality that has no phylogenetic significance for the leporids.—MARY R. DAWSON, *Museum of Natural History, University of Kansas, Lawrence, Kansas.* *Received October 20, 1955.*

INTENTIONAL REMOVAL OF A DISTURBING OBJECT BY AN ATLANTIC BOTTLENOSE DOLPHIN

That captive Atlantic bottlenose dolphins, *Tursiops truncatus* Montague, will often play with objects with which they may come in contact has already been fully documented by Townsend (Zoologica, 1(16): 290, 1914), McBride and Hebb (Jour. Comp. and Physiol. Psych., 41: 116–17, 1948), McBride (Nat. Hist., 45: 28, 1940), and Essapian (Nat. Hist., 62: 392, 396, 1953). Some of these objects of play as described by the above writers are: a floating box, rubber inner tube, partly deflated rubber ball, pieces of rock or shell, colored disks, dead fish, and even live fish and turtles, which are caught and released unharmed, and, in the case of one large turtle, was stood up on edge and pushed all the way across the tank and up against the far wall. McBride and Kritzler (Jour. Mamm., 32: 260–62, 1951), working at Marine Studios, Marineland, Florida, gave several cases of apparently definite purposeful *play*, described as requiring considerable cerebral development. The objects involved in this play were feathers and pieces of food. However, there seems to be no published record of a dolphin apparently intentionally removing a foreign object when that object seemed to interfere with its current activity.

In this case, the object was a very small Atlantic Ridley turtle, *Lepidochelys kempii* (Garman). "Steamboat" lives with three adult Atlantic bottlenose dolphins in the large circular tank at the Gulfarium, The Living Sea, Fort Walton Beach, Florida. Part of the show at the Gulfarium is *Feeding Time*, when the dolphins are made to jump from the water to accept food from an attendant. The turtle, in attempting to get some of the fish being fed the Dolphins, often maneuvered itself into a position directly under the hand of the attendant, and thus in the spot where the dolphins were jumping. It was frequently noted, and has even been included in the announcer's talk, that when the Ridley became especially bothersome to the dolphins' activity, one of them would grasp it in its mouth and quickly swim with it to the other side of the tank, where it would leave the turtle and rapidly return to the feeding point. Sometimes the turtle was successful in securing a fish. In this case, the dolphins would usually quickly seize the fish rather than carry "Steamboat" away. Since there was abundant food available, there was no need for the dolphin to compete for the

fish. Thus this activity may have been another attempt to discourage the bothersome turtle, though I have seen dolphins seize food from large Atlantic loggerhead turtles, *Caretta caretta* (Linnaeus), at Marine Studios, apparently in play.

McBride and Hebb (*loc. cit.*) alluded to the fact that the playful behavior they described was learned by imitation from the other dolphins in the Marine Studios tank. Since there had never been any other floating objects in the Gulfarium tank for the dolphins to play with, and since they had never been observed taking food from the larger turtles in the tank, they could not have acquired this behavior there and transferred it to the Ridley. Therefore, if the behavior was learned in this case, it had to have been acquired in the wild state before capture.

Thus, this seemingly purposeful activity on the part of the dolphins is another example of highly developed patterns of evidently innate behavior in this group of marine mammals, (see Siebenaler and Caldwell, Jour. Mamm., 37: 1956, for an example of innate purposeful cooperation among captive and wild adult dolphins).

I thank Dr. Archie Carr of the University of Florida for his helpful criticisms of the manuscript; and Mr. and Mrs. J. B. Siebenaler, Mr. Winfield Brady, and Mr. James Cline, all of The Living Sea, for introducing me to "Steamboat's" antics and for their help in assembling the data for this paper.—David K. Caldwell, *Department of Biology, University of Florida, Gainesville. (A contribution from the Department of Biology, University of Florida, and Contribution No. 2 from The Living Sea, Fort Walton Beach, Florida).* *Received October 13, 1955.*

AN UNREPORTED SPECIMEN OF THE WHALE, *BALAENOPTERA PHYSALUS*

A whale 63 feet long, unpresented to science since its capture in 1897 on the shores of Long Beach, California, is herein identified as *Balaenoptera physalus*. The author, with the gratifying aid of Miss Anita Daugherty of the California State Fish and Game laboratories at Terminal Island, has found his drawings and photographs of the subject specimen to compare favorably with those of True (Smithsonian Contr. Knowledge, 33, 1904).

This specimen became available to me for study in May, 1955, at Colorado Lagoon in Long Beach, when I was employed by the city to reassemble and preserve the skeleton. Overall length of skull is 4775.2 mm.; total width at pre-orbital prominance is 1987.9 mm.; at zygoma is 2108.2 mm.; the length of rami is 4737.1 mm. (following outside curve); shortest length, 4603.7 mm. Some bones are lacking, possibly victims of vandalism or inadequate preservation.

The bones were first reassembled in their proper anatomical relationship, numbered and grouped, such as "C1 to C7", 1st to 7th cervical. After this had been accomplished, each of the bones was washed individually with clear water; this was rather difficult, in that previously it was found that the park maintenance crew had tried to clean the skeleton with boraxo granules, which caked in the porous portion of the bone. After scrubbing the bone with a brush, a 60 per cent alvar solution was prepared and painted on each bone with a paint brush; two coats were needed to give adequate protection. In various cranial cavities where a brush was impractical, the solution was cut down to 50 per cent alvar and sprayed with a fly insecticide gun; this worked out well especially in the area of the auditory bulla. The stapes were found to be in position in the tympanic cavity; and after photographs and drawings were made, with the ossicle in place and out, it was then sealed in position and left.

After the drying of the alvar, india ink was used to number the bones; they were then placed in cases for storage.

The history of this skeletal exhibit is unique, having been first housed in an articulated arrangement in the Long Beach City Library, a municipal pier, and finally in a special structure in a city park. When the whale came under my care, 58 years after its capture, the bones had become disarticulated through weathering, breakage and vandalism. The specimen sorely needed rearticulation in an anatomically proper manner.

This specimen was captured on May 20, 1897, by two boys, Arthur Hewitt and Lewis

Lang, as it lay supposedly asleep 150 yards off the water's edge in the city of Long Beach. According to news accounts of the day and letter from Mr. Arthur Hewitt to Dr. M. Dale Arvey of Long Beach State College, the boys sought help from nearby house movers; and with the aid of mules and heavy equipment, they drew the struggling whale aground. Subsequent actions made the whale a property of the City of Long Beach. The defleshing and preparation of the skeleton was done locally with improvised equipment.

Acknowledgment: I wish to thank Carl L. Hubbs for a tentative confirmation of this identification (letter June 8, 1955, to R. G. Miller), and R. G. Miller for his great help in the preparation of this paper.—James V. A. Conkey, *1030 Loma Avenue, Long Beach, California.* *Received July 25, 1955.*

PSEUDORCA CRASSIDENS OWEN FROM MEDITERRANEAN SHORES OF EGYPT

A fragment of the skull of a false killer whale has recently been found on the Mediterranean coast of Egypt, two miles north of Baltim, a fishing town on Lake Burullus, Fouadiya Province. The specimen is on deposit at the Museum, Department of Zoology, Ein Shams University, Cairo. It consists of the left maxillary bone and has nine alveoli, the ninth alveolus is the smallest. The row of alveoli extends backwards almost to the antorbital notch, at the base of the rostrum. Dr. Remington Kellogg, Director of the U. S. National Museum, has examined photographs of the specimen and identified it as *Pseudorca crassidens* Owen, 1846. The whale has not previously been known from the coastal districts of Egypt. Flower (Proc. Zool. Soc. London, 1932: 405) stated that of the Delphinidae only two species are regular inhabitants of the Egyptian coastal waters, they are the large and leisurely *Tursiops truncatus* and the smaller and more agile *Delphinus delphis*, both these kinds of dolphins are to be seen frequently in Port Said harbour. How frequently the false killer whale visits the Mediterranean shores of Egypt is yet to be determined.—Kamal Wassif, *Department of Zoology, Faculty of Science, Ein Shams University, Cairo, Egypt.* *Received September 29, 1955.*

SOUTHERN RIGHT WHALE IN AUSTRALIAN WATERS

The importance of the southern right whale (*Balaena australis* Desmoulins) in the early settlement of Australia is not generally recognised. The pursuit of this whale brought many of the first non-convict settlers to Australian (especially Tasmanian) shores. In fact a whaler carried the first settlers to Tasmania in 1803, and for the next forty years this new colony was mainly engaged in the pursuit of the southern right whale, as reviewed by Dakin (WHALEMEN ADVENTURERS, 1934).

This species was once abundant along the southern coast of Australia and around New Zealand between May and October, the females entering sheltered bays to calve and nurse their young (Dieffenbach, TRAVELS IN NEW ZEALAND, I, 1843; Pearson, Pap. and Proc. Roy. Soc. Tasmania, 1935: 166–167, 1936). At this phase they were relatively easily killed, beached and stripped of blubber and baleen. Thus "bay whaling" commenced in Tasmania and rapidly extended along the southern coast of Australia and to New Zealand, reaching a peak about 1840. Dakin records that in 1841 there were 35 bay whaling stations in Tasmania alone. As well as the bay whaling stations, many whaling ships ranged along the southern coast of Australia taking southern right whales and sperm whales. It is said that in 1841 there were nearly 300 American and French whalers along the southern coast of Australia.

The practice of indiscriminately killing the calves as well as females about to calve, was criticised as early as 1832 by Hay (see Dakin) and in 1839 by Dieffenbach (1843), both warning that the southern right whale would soon be exterminated in this way. This theory was quickly verified as bay whaling began to decline from 1840, and by 1843 southern right whales were becoming scarce in this area. The pursuit of this species soon ceased and the sperm whale was hunted more intensively.

The damage thus done to this stock of southern right whales was so severe that in the present century (in spite of full protection) individuals of this species have been rarely

sighted along the Australian coast: in fact I can find no such published records. Wood Jones (THE MAMMALS OF SOUTH AUSTRALIA III, 1925) noted that in the previous fifty years no specimens had been stranded or captured along this coast.

However, on August 2, 1955, a pair of southern right whales were sighted in Frenchman's Bay, close to Albany, Western Australia. Due to the co-operation of the manager of the Cheynes Beach Whaling Company (which operates a whaling station at Frenchman's Bay), I was able to observe these whales at close quarters from a launch.

This pair consisted of a female approximately 55 feet, and a calf 18 to 20 feet, in length. Both appeared to be healthy. They spent the greater part of the day in shallow water (2–3 fathoms) close to shore. When approached they were lying quietly at the surface, then moved leisurely (at about 2 knots) along the shallows, making no effort to reach deeper water. On three occasions the 36 foot launch scraped over the female's back, but apart from a temporary increase in speed, this did not appear to unduly disturb these whales.

The calf kept very close to the cow, which turned the calf by physical contact: this sometimes resulted in the calf sliding over the cow's back, almost clear of the water. The callosity upon the snout, known as the 'bonnet' was well developed in the calf as well as in the cow.

While following these whales, the intervals between successive blows were recorded for the adult. The first set of intervals were 35, 120, 63, 42, 28, 128, 50, 43, 20 seconds, and in a further series of blows the intervals were 120, 75, 180, 40, 50 and 20 seconds. There appeared to be a fairly regular periodicity in the blows; one after an interval of two minutes or more was followed by briefer soundings of down to 20 seconds, followed by another longer sounding of two to three minutes. After a brief sounding the blow was not very distinct, but after a longer sounding the blow had the characteristic V-shaped appearance figured by Matthews (Discovery Repts., 17: 169–182, 1938). The calf tended to blow more frequently than the cow, but sometimes sounded for up to two minutes.

In view of the apparent rarity of the southern right whale in spite of long protection, it is hoped that any further sightings will be fully recorded.—R. G. CHITTLEBOROUGH, C.S.I.R.O., Division of Fisheries, % *University of W.A., Nedlands, Western Australia. Received November 7, 1955.*

MULE DEER RECORD FOR IOWA

During the 1954 deer season, Osmer Sissel, a farmer living near Leon, Decatur County, Iowa, killed a deer on his farm. Mr. Sissel, 71 years of age and a native to this section of Iowa, had seen only three of four deer in the previous four years and did not expect to see a deer during the season. Fortunately, he took the deer to the biology checking station located approximately 13 miles north of Leon at the Decatur-Clarke County line. Although the hunter knew only that he had bagged a deer, Robert Barratt, Area Game Manager and Elden Stempel, Quail Biologist, of the Iowa Conservation Commission who were operating the checking station, recognized the animal as a yearling mule deer. They weighed and aged the 1½ year old buck and obtained the head and tail. It weighed 116 pounds, hog-dressed, but with the heart and lungs still in the carcass. There was one antler, the left one, and it was forked.

While visiting the checking station during the second day of the season, the writer checked the head and tail. After the skull was cleaned it was sent to Dr. A. Starker Leopold who kindly verified our identification. He reported that the skull was considerably larger than the skull of yearling mule deer taken in northeastern California of the large race *O. h. hemionus* although the hog-dressed weight was approximately what they would expect in yearling bucks there. Although the writer did not see this animal, one of the men who checked it reported that it was in average condition for the deer that they saw, while the other man reported that it was not particularly skinny, but remembered that it was not as fat as the "native" white tails.

Although verbal reports of mule deer in Iowa have been received from several locations the past few years, none were verified. After this animal was killed and identified there were reports of ten or more mule deer in a nearby location. A preliminary search of the area

with the local conservation officer failed to locate any additional mule deer. Inquiries among sportsmen and farmers by the conservation officer revealed no information regarding releases of deer in this vicinity.

This is the first recent record for the mule deer in Iowa although four blacktailed (mule) deer were reported by Audubon on May 12, 1843 just north of the Sioux Pictout River (Little Sioux River) (ANNALS OF IOWA, 1928). This would place them in what is now northwestern Harrison County, Iowa. Scott (Ia. State Coll. Jour. Sci., 12: 43–97, 1937) does not mention mule deer in his list of the mammals of Iowa. Wampole and Fichter (Nebr. Game, Forestation and Parks Comm., Wildlife Mgt. Notes, 1: 15–18, 1949) report that the white tailed deer was found eastwardly, and the mule deer westwardly, in Nebraska and that "The ranges of the two species overlap in the central part of the state." Sather (1955, *in litt.*) writes "Mule deer are by no means rare as far east as Dakota County, although they are far outnumbered by white-tailed deer." Gunderson (Jour. Mamm., 29: 184, 1948) and Erickson and Bue (Jour. Mamm., 35: 457–458, 1954) reported the recent extension of the mule deer range into Minnesota.

With the nearest known mule deer in Dakota County, Nebraska, approximately 180 airline miles from Leon, Iowa, this extends its reported range some 130 miles to the east and 100 miles to the south into Iowa.

The skull, GCS #841, is in the possession of the Iowa Conservation Commission.—GLEN C. SANDERSON, *Iowa Conservation Commission, Marion, Iowa. Received September 8, 1955.*

AGGRESSIVE BEHAVIOR OF MULE DEER TOWARD BOBCAT

A number of observations of aggressive behavior of mule deer (*Odocoileus hemionus*) toward bobcats (*Lynx rufus*) have been published by Linsdale and Tomich (A HERD OF MULE DEER, Univ. Calif. Press, Berkeley, pp. 258–275, 1953). The following observations are offered as a record of similar behavior.

For several days a doe and her two fawns were seen in a certain location in the chaparral vegetation near Prescott, Arizona. On the morning of August 27, 1953, the doe was observed standing in one spot, and the fawns were bedded about 100 yards away. As the doe was being watched, she grew excited and wheeled and trotted about at the sight of a mature bobcat walking up the grassy bottom of the valley. By now, the bobcat had passed 150 yards to the side of the fawns, and there was, consequently, no reason to think he was molesting them. Nevertheless, the deer raced toward the bobcat. The bobcat jumped out of her path, ran the short distance to a dense clump of brush, and darted in, with the deer about ten feet behind. For several minutes the doe ran around the clump of brush, stopping now and then to peer inward. For several minutes more she stood nearby, then walked up the slope to where her fawns were lying. The bobcat did not come out of the thicket during this time.

Throughout the encounter the bobcat was obviously afraid of the doe. It would be important to know how common such behavior of mule deer is, and how successful it is in repelling bobcats. The behavior of both animals in this case, and in the cases reported by Linsdale and Tomich, suggests that mule deer may by such attacks prevent a considerable proportion of the predation attempts of bobcats upon the fawns.—WILLIAM R. HANSON, *Illinois Natural History Survey, Urbana. Received August 15, 1955.*

THE APPEARANCE OF A MOOSE RUTTING GROUND

While traversing a portage in Quebec, Canada, on September 1, 1954, that had fallen into disuse, I was fortunate to find a moose (*Alces alces*) rutting ground. The area lies 175 airline miles north northwest of Montreal on the southeast bank of the Simard River just before it empties into Lake Dandurand. The portage, from all reports, had not been used for some six years and amounted to merely a blazed trail around rapids in the river. This trail led through an open park-like stand of jack pine (*Pinus banksiana*) with an undergrowth of low bush blueberry (*Vaccinium pennsylvanicum*) growing on well-drained sand,

which forms low, rolling hills about 200 feet above the level of the river. The vegetation here is unusual since the greatest share of this country is covered with dense, almost pure stands of black spruce (*Picea mariana*) with ground cover of deep sphagnum moss.

The rutting ground was situated on the southern side of a low hill with a slope of about 20 per cent. The wallows were about eight feet across, an average of one foot deep and about thirty to forty feet apart. No vegetation grew in these depressions, of which there were four, and the sand from the holes had been pushed out to form a rim or parapet around each one to a height of perhaps six inches. There was some tendency for the wallows to appear ellipsoidal, rather than round, and the longer of the two axes ran along the contour of the hill. There was no evidence or odor of the various glandular secretions normally extruded into wallows, nor was there evidence of recent use.—HOWARD E. WOODIN, *Department of Biology, Middlebury College, Middlebury, Vermont.* *Received November 19, 1955.*

DID THE PLIOCENE HORSE *PLIOHIPPUS* EAT HACKBERRIES

While collecting the skull and partial skeleton of an early Pliocene *Pliohippus* from the semi-consolidated Ogallala sands near Rosebud Agency, Todd County, South Dakota, the authors found a large number of *Celtis* seeds intermixed with the bones and surrounding sediments. Of particular interest was a round compacted mass of these seeds about three inches in diameter which lay within the mass of bones. While the skeleton was not articulated so that one could say where the stomach might have been, it is suggested that this mass might well represent the stomach contents.

While the possibility that this mass of seeds may have been a Pliocene rodent's cache cannot be entirely ruled out there was no evidence that such might have been the case.

We postulate that the mass of seeds represents the stomach contents of this horse at the time of its death and that following the desiccation of its body the seed mass was held together by the mummified stomach until the skeleton was buried by the fine sand in which it was preserved.—J. R. MACDONALD and SHERRILL SWENSON, *Museum of Geology, South Dakota School of Mines and Technology, Rapid City.* *Received October 5, 1955.*

REVIEWS

DuBrul, E. Lloyd, and Harry Sicher. THE ADAPTIVE CHIN. Charles C Thomas, Springfield, Illinois. ix plus 97 pp., frontispiece, 47 figs. 1954. Price, $3.50.

This little book, which seems to have escaped the notice of most if not all zoological bibliographical services deserves to be rescued from such oblivion. The book is co-authored by a dentist and an M. D., but both are primarily anatomists, and they have produced a small but fine evolutionary study on the functional anatomy of mammals. Man is an actor on their stage, true, but so are several other Primates, as well as representatives of the Lagomorpha, Carnivora, and Notoungulata. Skillfully, the authors have chosen evolutionary experiments, that have occurred or are occurring in nature, from which to garner their evidence.

The human chin is really incidental in this study, although it has loomed large in some "scientific" racist literature, here thoroughly discredited. Primary consideration is the relation between semi-erect or fully erect posture and concomitant evolutionary changes in the head. Data of comparative anatomy and paleontology are used to show that as the posture becomes more erect, whether in Primates, Leporidae, or Hegetotheriidae, the occipital foramen moves forward and opens more vertically, the face bends down in front, the lower jaws spread and each deepens while its angle tends to disappear, the lower jaws shorten, and the inward stress placed upon the mandible by the contraction of the M. pterygoideus externus is increased. This increased pull on the more flaring mandibles is counterbalanced by bracing at the symphysis, which bracing takes various forms: a longer symphysis in *Lepus*, as compared with *Ochotona*, fusion at the symphysis in the Anthropoidea, a "simian shelf" in the Pongidae, and a chin in *Homo*. This latter animal has the

lower jaw so retracted, in correlation with possessing the most erect posture among mammals, that a simian shelf or an elongate symphysis would physically impinge upon the vital tubes for feeding and breathing, so the bracing bone instead comes to lie upon the front of the symphysis, and this is the chin.

Thus the chin is really but a minor episode in a series of events that had their beginnings long ago in changes in ankle and pelvis.

The mechanical function of the chin, which has nothing to do with speech, tongue muscles, facial muscles, or Nordic supremacy, is neatly demonstrated by the "stress-coat" technique.

In general, the book is uncluttered with the anatomical minutiae too often found in studies in comparative anatomy; where necessary, as in the discussion of the M. pterygoideus externus, detail is given, but the reader is assumed to know his basic anatomy and the conclusions are drawn in broad strokes, with the aid of cleanly drawn figures. Even if one did not read the text, the figures would tell the story (and don't miss the frontispiece!). —CHARLES A. REED, *College of Pharmacy, University of Illinois, Chicago 12.*

BRIEFER NOTICE

Harper, Francis. THE BARREN GROUND CARIBOU OF KEEWATIN. Univ. Kansas Mus. Nat. Hist. Misc. Publ. No. 6. 163 pp., 28 figs. (halftones), 1 map. 1955. Price $1.50 (paper) from Arctic Institute of North America, 1530 P Street, N.W., Washington 5, D. C.

"This is an intimate study of an animal whose annual migrations constitute one of the mightiest spectacles of wild life in all of North America. It is based upon observations made during a six months' sojourn in the Nueltin Lake region, Keewatin, under the auspices of the Arctic Institute of North America. It discusses migrations, ecology, numerical status, general habits, morphology, and taxonomy. Special attention is given to the influence of weather, food supply, and insects on the distribution of the Caribou, and to the relations of these animals to Eskimos and Indians, Black Bears, Wolves, and insect tormentors and parasites. The voice of the fawns, the seasonal changes of pelage and antlers, and measurements of the animals (including skulls and antlers) are among the many other subjects treated in this exceptionally full account of the life history of *Rangifer arcticus arcticus*. Migrant herds fording and swimming a river, and passing within a rod of the photographer, are included in the 28 halftone figures. A remarkable warning posture of the Caribou, scarcely touched upon in the previous literature, is portrayed in a cover drawing by Earl L. Poole. There are a very ample bibliography and an index." (From press release by the Arctic Institute of North America.)

Jones, I. Chester and P. Eckstein (Editors). THE COMPARATIVE PHYSIOLOGY OF REPRODUCTION AND THE EFFECTS OF SEX HORMONES IN VERTEBRATES. Memoirs of the Society for Endocrinology. New York: Cambridge University Press. 253 pp., illus. Price, $8.50.

The papers contained in this publication are from a Symposium on the Comparative Endocrinology of Vertebrates held at the University of Liverpool in July, 1954.

Of particular interest to mammalogists will be the papers entitled "Reproduction in Mammals" by S. Zuckerman and P. Eckstein; "The Evolution of Viviparity in Vertebrates" by L. Harrison Mathews; "Vertebrate Gonado-tropins" by E. Witschi; "The Varying Effects of Sex Hormones in Mammals" by J. H. Leathem and R. C. Wolf; and "Modalities in the Action of Gonadal and Gonad-stimulating Hormones in the Foetus" by H. Jost.

The memoir also contains papers on similar subject matter for fish, amphibia, reptiles, and birds.

Halloran, Patricia O'Connor. A BIBLIOGRAPHY OF REFERENCES TO DISEASES OF WILD MAMMALS AND BIRDS. Amer. Jour. Veterinary Research, vol. 16, no. 61 (part 2), 465 pp. 1955. Price, $10.00 (paper). American Veterinary Medical Association, 600 South Michigan Avenue, Chicago 5.

Extensive bibliographies of this type are invaluable to workers in the field covered and in related fields of study as well. Despite the title, this bibliography contains numerous references on non-disease subjects. Under the various taxonomic groupings (Orders, Fam-

ilies) there are listings by diseases and anatomical systems, and a "General" and a "Miscellaneous" listing that includes such topics as longevity, care and management, nutrition, albinism, physiology, and many others.

As the author points out, no such bibliography can be complete, but the thousands of references contained in this publication will long continue to serve a most useful purpose. The author deserves the thanks of all who will use it, and is to be congratulated for this successful culmination of many years of work.

Dobzhansky, Theodosius. EVOLUTION, GENETICS, AND MAN. John Wiley and Sons, Inc., New York. 398 pp., illus. 1955. Price, $5.50.

This is a fresh and up-to-date introductory text on the subject of evolution and genetics. Only enough elementary genetics is provided to give a proper understanding of the discussions on evolution.

While man is featured in many discussions, the treatment is by no means restricted and the applications of modern genetics to evolution in other animals and plants occupies much of the text. Some titles of later chapters will give a fair idea of the range of the discussions: "Natural Selection and Adaptation"; "Individuals, Populations, and Races"; "Species"; "Evolution under Domestication and Evolution by Polyploidy"; "Evolution of the Organic Form and Function"; "Evolution of Sex"; "Historical Record of Organic Evolution"; "Human Evolution"; and "Chance, Guidance, and Freedom in Evolution."

The text is very well organized with ample sub-headings in bold-face. Many illustrations are presented to clarify the text. An admirable feature is the presence of annotated lists of suggested readings at the end of each chapter.

RECENT LITERATURE

(Conducted by David H. Johnson, Claude W. Hibbard, Charles P. Lyman, Richard H. Manville, and Henry W. Setzer)

[Reprints of this section may be purchased from the Corresponding Secretary]

ADAM, KARL DIETRICH. Elephas meridionalis Nesti aus den altpleistozäen Goldshöfer Sanden bei Aalen (Württemberg). Eiszeitalter und Gegenmart, vol. 3, pp. 84–95, illus. July, 1953.

ADAM, KARL DIETRICH. Die Bedeutung der altpleistozänen Saügetier-Faunen Südwestdeutschlands für die Gliederung des Eiszeitalters. Geol. Bavarica, Munich, no. 19, pp. 357–363, illus. December, 1953.

ADAM, KARL DIETRICH. Die mittelpleistozäen Faunen von Steinheim an der Murr (Württemberg). Quaternaria, Rome, vol. 1, pp. 131–144, illus. 1954.

ADAMS, W. E. The carotid sinus complex "parathyroid" III and thymoparathyroid bodies, with special reference to the Australian opossum Trichosurus vulpecula. Amer. Jour. Anat., vol. 97, no. 1, pp. 1–58. July, 1955.

AELLEN, VILLY. *Rhinolophus blasii* Peters (1866), chauve-souris nouvelle pour l'Afrique du Nord. Mammalia, Paris, vol. 19, no. 3, pp. 361–366, illus. September, 1955.

ALLEN, ROSS, AND WILFRED T. NEILL. The eastern gray squirrel. Florida Wildlife, Tallahassee, vol. 9, no. 5, pp. 7, 49, illus. October, 1955.

AMEEL, DONALD J. Parasites of the coyote in Kansas. Trans. Kansas Acad. Sci., vol. 58, no. 2, pp. 208–210. June 21, 1955.

ANDERSON, SYDNEY. Small mammals from Gilliam County, Oregon. Murrelet, Seattle, vol. 36, no. 2, pp. 26–27. August, 1955.

ANONYMOUS. Gezelschap voor een Capibara. Artis, Amsterdam, vol. 1, no. 3, pp. 60–61, illus. October, 1955.

ANONYMOUS. Babyverwisseling bij Kangeroes. Artis, Amsterdam, vol. 1, no. 3, pp. 69–70, illus. October, 1955.

ANONYMOUS. Kleine grote Koedoes. Artis, Amsterdam, vol. 1, no. 3, pp. 71–74, illus. October, 1955.

ARDEN, G. B., AND KATHARINE TANSLEY. The spectral sensitivity of the pure-cone retina of the souslik (*Citellus citellus*). Jour. Physiol., Cambridge, England, vol. 130, no. 1, pp. 225–232. October, 1955.

ASHTON, E. H. Some characters of the skulls of the European polecat, the Asiatic polecat and the domestic ferret. (Addendum.) Proc. Zool. Soc. London, vol. 125, pts. 3–4, pp. 807–809, illus. November 23, 1955.

BAKER, ROLLIN H. A new species of bat (genus Myotis) from Coahuila, México. Proc. Biol. Soc. Washington, vol. 68, pp. 165–166, illus. December 31, 1955. (New: *M. planiceps*.)

BAKER, ROLLIN H., AND HOWARD J. STAINS. A new long-eared Myotis (Myotis evotis) from northeastern México. Univ. Kansas Publ., Mus. Nat. Hist. vol. 9, no. 3, pp. 81–84. December 10, 1955. (New: *M. e. auriculus*.)

BAUER, KURT. Die Streifenmaus (*Sicista subtilus trigona* Petenyi) in Österreich. Zool. Anzeiger, Leipzig, vol. 152, nos. 9–10, pp. 206–213. May, 1954.

BAUER, KURT. Zu Ökologie und Verbreitung der zweifarbigen Fledermaus (*Vespertilio discolor* Natterer) in Österreich. Zool. Anzeiger, Leipzig, vol. 152, nos. 11–12, pp. 274–279. June, 1954.

BECKER, E. L., J. A. SCHILLING, AND R. B. HARVEY. Renal function and electrolytes in the llama. Amer. Jour. Physiol., vol. 183, no. 2, pp. 307–308. November, 1955.

BEER, JAMES R. Movements of tagged beaver. Jour. Wildlife Management, vol. 19, no. 4, pp. 492–493. October, 1955.

BELL, J. FREDERICK, W. J. HADLOW, AND WILLIAM L. JELLISON. Chiropteran rabies in Montana. Public Health Repts., U. S. Public Health Service, Washington, vol. 70, no. 10, pp. 991–994. October, 1955.

BELYAEVA, E. I. About the remains of a mastodon from Ulan-Tologoi. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 41, pp. 78–86, illus. 1952. (New: *Serridentinus tologojensis*.)

BELYAEVA, E. I. Primitive rhinoceros-like (mammals) from Mongolia. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 41, pp. 120–143, illus. 1952. (New: *Parahyracodon, P. monogliensis, P. kazachstanensis*.)

BELYAEVA, E. I. New materials on Tertiary rhinoceros-like (mammals) from Kazakhstan. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 47, pp. 24–54, illus. 1954. (New: *Aprotodon borissiaki, Prothyracodon turgaiensis*.)

BELYAEVA, E. I. On finds of Anchithere in Kazakhstan. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 47, pp. 55–60, illus. 1954.

BELYAEVA, E. I. Occurrence of Russian Chalicotheres in Mongolia. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 55, pp. 44–84, illus. 1954.

BELYAEVA, E. I. Notes on some Oligocene Rhinoceroses of Mongolia. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 55, pp. 190–205, illus. 1954. (New: *Symphysorrhachis, S. brevirostris; Allacerops turgaica minor*.)

BILBEY, D. L. J., AND T. NICOL. Normal blood picture of the guinea pig. Nature, London, vol. 176, no. 4495, p. 1218. December 24, 1955.

BLANCHET, MAURICE. Le "marquage" probable du territoire, chez le castor du Rhone. La Terre et la Vie, Paris, vol. 102, no. 4, pp. 329–335, illus. December, 1955.

BLANCOU, LUCIEN. The lowland gorilla. Animal Kingdom, New York Zool. Soc., vol. 58, no. 6, pp. 162–169, illus. December, 1955.

BONNER, W. NIGEL. Reproductive organs of foetal and juvenile elephant seals. Nature, London, vol. 176, no. 4490, pp. 982–983, illus. November 19, 1955.

BORISSIAK, A. A. On the oldest Acerathere from Kazakhstan. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 47, pp. 5–23, illus. 1954.

BOURLIÈRE, FRANÇOIS. Mammals of the World. Knopf, New York, 223 p., illus. 1955.

BREATHNACH, A. S. Observations on endocranial casts of recent and fossil cetaceans. Jour. Anat., Cambridge, England, vol. 89, pt. 4, pp. 532–546. October, 1955.

BRIDGES, WILLIAM. The cheetah—the mildest cat. Animal Kingdom, New York Zool. Soc., vol. 58, no. 5, pp. 130–134, illus. October, 1955.

BURROUGHS, R. D. Bugles in the forest. Michigan Conserv., Lansing, vol. 24, no. 5, p. 33. October, 1955. (Elk)

BURTON, MAURICE. Elephants in gentler mood. Illus. London News, vol. 137, no. 3571, p. 574. October 1, 1955.

BURTON, MAURICE. Hippos at home and at school. Illus. London News, vol. 137, no. 3573, p. 664, illus. October 15, 1955.

BURTON, MAURICE. Hedgehogs' weights and ecstatic measures. Illus. London News, vol. 137, no. 3575, p. 774, illus. October 29, 1955.

BURTON, MAURICE. A fox sees red. Illus. London News, vol. 137, no. 3576, p. 792. November 5, 1955.

BURTON, MAURICE. Inquest on rabbits. Illus. London News, vol. 137, no. 3578, p. 880, illus. November 19, 1955.

BURTON, MAURICE. Gorillas at home. Illus. London News, vol. 137, no. 3580, p. 968, illus. December 3, 1955.

BURTON, MAURICE. When giraffes talk together. Illus. London News, vol. 137, no. 3581, p. 1018, illus. December 10, 1955.

BURTON, MAURICE. A dazzle of zebras. Illus. London News, vol. 137, no. 3584, p. 1142, illus. December 31, 1955.

BUTCHER, DEVEREUX. Seeing America's wildlife in our national refuges. Devin-Adair, New York, 338 pp., illus. 1955.

BUWALDA, J. P., AND G. E. LEWIS. A new species of Merychippus. Prof. Paper U. S. Geol. Surv., no. 264-G, pp. 147–152, illus. 1955. (New: *M. tehachapiensis*.)

CARP, BERNARD. The black devil of the Ituri Forest. African Wild Life, Johannesburg, vol. 9, no. 4, pp. 275–280, illus. December, 1955. (Gorilla)

CHITTLEBOROUGH, R. G. Puberty, physical maturity, and relative growth of the female humpback whale, *Megaptera nodosa* (Bonnaterre), On the Western Australian coast. Australian Jour. Marine & Freshwater Research, Melbourne, vol. 6, no. 3, pp. 315–327. October, 1955.

CHRISTIAN, J. J. Effect of population size on the adrenal glands and reproductive organs of male mice in populations of a fixed size. Amer. Jour. Physiol., vol. 182, no. 2, pp. 292–300. August, 1955.

CLARKE, ROBERT. A giant squid swallowed by a sperm whale. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), vol. 44, no. 10, pp. 589–593, illus. October, 1955.

COPE, JAMES B. A preliminary report on bat banding in Indiana. Proc. Indiana Acad. Sci., vol. 64, pp. 284–286. 1955.

COWAN, I. McT. An instance of scabies in the marten (*Martes americana*). Jour. Wildlife Management, vol. 19, no. 4, pp. 499. October, 1955.

CROMPTON, A. W. On some Triassic cynodonts from Tanganyika. Proc. Zool. Soc. London, vol. 125, pts. 3–4, pp. 617–669, illus. November 23, 1955.

CRUNDEN, CHARLES W., AND GEORGE O. HENDRICKSON. Evaluation of techniques in estimating a Mearns cottontail population. Proc. Iowa Acad. Sci., vol. 62, pp. 498–501. December, 1955.

DAS, F. M. Studies on *Funambulus palmarum tristriatus* Waterhouse (the Indian palm squirrel): Part 1. The musculature. Jour. Zool. Soc. India, vol. 7, no. 1, pp. 57–82. June, 1955.

DAVIS, DAVID E. Social interaction of rats as indicated by trapping procedures. Behaviour, Leiden, vol. 8, pt. 4, pp. 335–343. 1955.

DAVIES, D. V. Supra-sternal ossicles in primates other than man. Nature, London, vol. 176, no. 4493, p. 1130, illus. December 10, 1955.

DEKEYSER, P. L. Les mammifères de l'Afrique Noire Française. Inst. Français d'Afrique Noire, Initiation's Africaines, vol. 1, ed. 2, pp. 426. 1955.

DERANIYAGALA, P. E. P. Some stegodont elephantids. Spolia Zeylanica, Bull. Nat. Mus.

Ceylon, vol. 27, pt. 2, pp. 215–217. May 25, 1955. (New: *Stegodon (Sulcicephalus) szechuani*.)

Deraniyagala, P. E. P. The extinct Hippopotamus antiquus of Europe. Spolia Zeylanica, Bull. Nat. Mus. Ceylon, vol. 27, pt. 2, pp. 219–222. May 25, 1955.

Deraniyagala, P. E. P. The Ratnapura (Shivalik) fossils of Ceylon. Spolia Zeylanica, Bull. Nat. Mus. Ceylon, vol. 27, pt. 2, pp. 223–225. May 25, 1955.

Deraniyagala, P. E. P. Erythrism in the Ceylon porcupine *Acanthion leucurus*. Spolia Zeylanica, Bull. Nat. Mus. Ceylon, vol. 27, pt. 2, p. 287. May 25, 1955.

Deraniyagala, P. E. P. The sun bear of Ceylon. Spolia Zeylanica, Bull. Nat. Mus. Ceylon, vol. 27, pt. 2, pp. 289–290. May 25, 1955.

Deraniyagala, P. E. P. A new subspecies of jungle cat from South India. Spolia Zeylanica, Bull. Nat. Mus. Ceylon, vol. 27, pt. 2, p. 291. May 25, 1955. (New: *Felis chaus valbalala*.)

Didier, Robert. L'os pénien des ecureuils de l'Amérique du Sud. Mammalia, Paris, vol. 19, no. 3, pp. 416–426, illus. September, 1955.

Dorst, Jean. A propos des noms scientifiques de quelques mammifères. Mammalia, Paris, vol. 19, no. 3, pp. 429–430. September, 1955.

Doutt, J. Kenneth. Terminology of microgeographic races in mammals. Systematic Zoology, vol. 4, no. 4, pp. 179–185. December, 1955.

Downs, Theodore. A fossil sea lion from the Miocene of the San Joaquin Hills, Orange County, California. Bull. Southern California Acad. Sci., vol. 54, pt. 2, pp. 49–56, illus. October 5, 1955.

Dunton, Sam. In the bag with Andy. Animal Kingdom, New York Zool. Soc., vol. 58, no. 6, pp. 176–178, illus. December, 1955. (Photos of orang-utan.)

Durrant, Stephen D. In defense of the subspecies. Systematic Zoology, vol. 4, no. 4, pp. 186–190. December, 1955.

Durrant, Stephen D., M. Raymond Lee, and Richard M. Hansen. Additional records and extensions of known ranges of mammals from Utah. Univ. Kansas Publ., Mus. Nat. Hist., vol. 9, no. 2, pp. 69–80. December 10, 1955.

Edmond-Blanc, François. Note sur l'époque des mises-bas des addax et des oryx. Mammalia, Paris, vol. 19, no. 3, pp. 425–426. September, 1955.

Edmond-Blanc, François. Contribution à l'étude des eléphants nains du Sud-Cameroun. Mammalia, Paris, vol. 19, no. 3, pp. 428–429. September, 1955.

Ehlers, Kurt. Tödliche Erkrankung und seltene Heilung eines Känguruhbockes (*Macropus rufus* Desm.) Zool. Garten, Leipzig, vol. 22, no. 1, pp. 110–112. 1955.

Eibl-Eibesfeldt, Irenäus. Ethologische Studien am Galápagos-Seelöwen, Zalophus wollebaeki Sivertsen. Zeitschr. Tierpsychol., Berlin, vol. 12, no. 2, pp. 286–303, illus. November, 1955.

England, D. The Barbary apes of Gibraltar. Zoo Life, London, vol. 10, no. 3, pp. 67–69, illus. Autumn, 1955.

Ertelt, Wolfgang. Untersuchungen über Körpergrösse und Knochenstruktur bei Säugetieren. Zool. Jahrb., vol. 74, no. 4, pp. 588–638. December 30, 1955.

Ewer, R. F. The fossil carnivores of the Transvaal caves: Machairodontinae. Proc. Zool. Soc. London, vol. 125, pts. 3–4, pp. 587–615, pls. 1–3. November 23, 1955.

Fearnhead, R. W., C. C. D. Shute, and A. d'A. Bellairs. The temporomandibular joint of shrews. Proc. Zool. Soc. London, vol. 125, pts. 3–4, pp. 795–806, 1 pl. November 23, 1955.

Findley, James S. Speciation of the wandering shrew. Univ. Kansas Publ., Mus. Nat. Hist., vol. 9, no. 1, pp. 1–68. December 10, 1955. (New: *Sorex vargrans obscuroides*, *S. v. longiquus*.)

Flerov, K. K. Pantodonts (Pantodonta) collected by the Mongolian Paleontological Expedition of Academy of Science U.S.S.R. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 41, pp. 43–50, illus. 1952. (New: *Archaeolambda*, *A. planicanina*, family Archaeolambdidae.)

FOLMER, C. J. Dokterspraktijk in Artis. III. Apen. Artis, Amsterdam, vol. 1, no. 3, pp. 62–63, illus. October, 1955.

FRASER, F. C. The dolphin family. Zoo Life, London, vol. 10, no. 3, pp. 74–78, illus. Autumn, 1955.

FRASER, F. C., AND P. E. PURVES. The "blow" of whales. Nature, London, vol. 176, no. 4495, pp. 1221–1222. December 24, 1955.

FRECHKOP, S. Compte rendu du baguage des chéiroptères en Belgique (de 1939 à 1952 inclus). Inst. Royal Sci. Nat. Belgique, Brussels, pp. 24, tables. 1955.

GEIGY, R. Observations sur les phacochères du Tanganyika. Rev. Suisse Zool., Geneva, vol. 62, pp. 139–163. November, 1955.

GEIS, AELRED D. Trap response of the cottontail rabbit and its effect on censusing. Jour. Wildlife Management, vol. 19, no. 4, pp. 466–472. October, 1955.

GIJZEN, A. Nouveaux hôtes rares et précieux: les echidnés. Zoo, Antwerp, vol. 21, no. 2, p. 45, illus. October, 1955.

GLOVER, FRED A. Black bear damage to redwood reproduction. Jour. Wildlife Management, vol. 19, no. 4, pp. 437–443, illus. October, 1955.

GODINA, A. Y. A new fossil giraffe from Mongolia. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 47, pp. 172–180, illus. 1954. (New: *Samotherium mongoliense*.)

GOSLIN, ROBERT M. Animal remains from Ohio rock shelters. Ohio Jour. Sci., vol. 55, no. 6, pp. 358–362. November, 1955.

GREER, KENNETH R. Yearly food habits of the river otter in the Thompson Lakes region, northwestern Montana, as indicated by scat analyses. Amer. Midland Nat., Notre Dame, vol. 54, no. 2, pp. 299–313, illus. October, 1955.

GROMOVA, VERA. The history of horses (genus *Equus*) in the Old World. Part I. Review and account of forms. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 17, 374 p., illus. 1949. (New: *Equus caballus chosaricus, E. c. latipes*.)

GROMOVA, VERA. The history of horses (genus *Equus*) in the Old World. Part II. Evolution and classification of the genus. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 17, 162 p., illus. 1949.

GROMOVA, VERA. A primitive tapir-like (mammal) from the Paleogene of Mongolia. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 41, pp. 99–119, illus. 1952. (New: *Ergilia, E. pachypierna*.)

GROMOVA, VERA. A new find of Anchithere in Mongolia. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 41, pp. 87–98, illus. 1952.

GROMOVA, VERA. Hipparion (genus Hipparion). Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 36, 477 p., illus. 1952. (New: *Hipparion moldavicum, H. platygenys, H. elegans, H. longipes, H. giganteum*.)

GROMOVA, VERA. On primitive carnivores from the Paleogene of Mongolia and Kazakhstan. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 41, pp. 51–77, illus. 1952.

GROMOVA, VERA. Amphibious rhinoceroses (Amynodontidae) of Mongolia. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 55, pp. 85–189, illus. 1954. (New: *Gigantamynodon, G. cessutor; Hypsamynodon, H. progressus*.)

HAINES, R. WHEELER. The anatomy of the hand of certain insectivores. Proc. Zool. Soc. London, vol. 125, pts. 3–4, pp. 761–777, illus. November 23, 1955.

HAMILTON, WILLIAM J., JR. Where do animals go in winter-time? Animal Kingdom, New York Zool. Soc., vol. 58, no. 6, pp. 170–175, illus. December, 1955.

HAMMEL, H. T. Thermal properties of fur. Amer. Jour. Physiol., vol. 182, no. 2, pp. 369–376. August, 1955.

HANDLEY, CHARLES O., JR. A new species of free-tailed bat (genus *Eumops*) from Brazil. Proc. Biol. Soc. Washington, vol. 68, pp. 177–178. December 31, 1955. (New: *E. amazonicus*.)

HARPER, FRANCIS. The Barren Ground caribou of Keewatin. Misc. Publ. Univ. Kansas Mus. Nat. Hist., Lawrence, no. 6, pp. 164, illus. October 21, 1955.

HARRISON, DAVID L. On a collection of mammals from Oman, Arabia, with the description

of two new bats. Ann. & Mag. Nat. Hist., ser. 12, vol. 8, no. 96, pp. 897–910. December, 1955. (New: *Triaenops persiscus macdonaldi*, *Taphozous nudiventris zayidi*.)

HAUGEN, ARNOLD O. More bucks to harvest. Alabama Conservation, vol. 27, no. 3, pp. 16–19, illus. November-December, 1955. (White-tailed deer)

HAYMAN, R. W. Notes on some African bats, mainly from the Belgian Congo. Rev. Zool. & Bot. Africaine, vol. 50, nos. 3–4, pp. 277–295. December 30, 1954.

HEDIGER, H. Mäuse im Zoo. Zool. Garten, Leipzig, vol. 22, no. 1, pp. 76–85, illus. 1955. (*Mus musculus*)

HEERDT, P. F. VAN, AND J. W. SLUITER. Longevity in bats. Natuurhist. Maandblad, vol. 44, nos. 3–4, pp. 35–36. April, 1955.

HEIM DE BALSAC, H., AND RENÉE GUISLAIN. Evolution et spéciation des campagnols du genre *Arvicola* en territoire français. Mammalia, Paris, vol. 19, no. 3, pp. 367–390, illus. September, 1955.

HELLER, FLORIAN. Neue Fundstellen altdiluvialer *Desmana*-Reste in Sudwestdeutschland. Neues Jahrb. Geol. & Paläontol., vol. 10, pp. 465–475. October, 1954. (New: *Desmana thermalis jockgrimensis; D. moschata westhofensis*.)

HERRE, WOLF, AND MANFRED RÖHRS. Über die Formenmannigfaltigkeit des Gehörns der Caprini Simpson 1945. Zool. Garten, Leipzig, vol. 22, no. 1, pp. 85–110, illus. 1955.

HERSHKOVITZ, PHILIP. On the cheek pouches of the tropical American paca, *Agouti paca* (Linnaeus, 1766). Säugetierk. Mitteil., Stuttgart, vol. 3, no. 2, pp. 67–70, illus. 1955.

HERSHKOVITZ, PHILIP. Status of the generic name *Zorilla* (Mammalia): nomenclature by rule or by caprice. Proc. Biol. Soc. Washington, vol. 68, pp. 185–192. December 31, 1955.

HERTER, KONRAD, AND MARGARETHE HERTER. Über eine scheinträchtige Iltisfähe mit untergeschobenem Katzenjungen. Zocl. Garten, Leipzig, vol. 22, no. 1, pp. 33–46, illus. 1955.

HIBBARD, CLAUDE W. Notes on the microtine rodents from the Port Kennedy cave deposit. Proc. Acad. Nat. Sci. Philadelphia, vol. 107, pp. 87–95, illus. November 23, 1955.

HILDEBRAND, M. Skeletal differences between deer, sheep, and goats. California Fish & Game, vol. 41, no. 4, pp. 327–346, illus. October, 1955.

HILL, W. C. OSMAN. Primates in the Royal Scottish Museum. Part 2, Platyrrhini. Proc. Royal Physical Soc. Edinburgh, vol. 24, pt. 3, pp. 49–62, pls. 4. December, 1955.

HILLEMANN, HOWARD H. Organization, histology, and circulatory pattern of the near-term placenta of the Guinea baboon, *Papio cynocephalus*, Demarest. Oregon State Monographs, Zool., no. 9, pp. 20, pls. 13. June, 1955.

HILTON, WILLIAM A. Brain chorioid plexuses of mammals. Bull. Southern California Acad. Sci., vol. 54, pt. 3, pp. 116–125. September-December, 1955.

HITCHCOCK, HAROLD B. A summer colony of the least bat, Myotis subulatus leibii (Audubon and Bachman). Canadian Field-Nat., vol. 69, no. 2, p. 31. April-June, 1955.

HOFFMEISTER, DONALD F., AND PHILIP H. KRUTZSCH. A new subspecies of *Myotis evotis* (H. Allen) from southeastern Arizona and Mexico. Nat. Hist. Misc., Chicago Acad. Sci., no. 151, pp. 4. December 28, 1955. (New: *M. e. apache*.)

HOLLING, C. S. The selection by certain small mammals of dead, parasitized, and healthy prepupae of the European pine sawfly, *Neodiprion sertifer*. Canad. Jour. Sci., Ottawa, vol. 33, no. 6, pp. 404–419, illus. December, 1955.

HOLMES, W. N. Variations in adrenal ascorbic acid concentration of the hamster during the pre-hibernatory period. Endocrinology, vol. 57, no. 4, pp. 409–413. October, 1955.

HOOGSTRAAL, HARRY, KAMAL WASSIF, AND MAKRAM N. KAISER. New mammal records for the Western Desert of Egypt. Bull. Zool. Soc. Egypt, no. 12 (1954), pp. 7–12. August 31, 1955.

HOYTE, H. M. D. Observations on reproduction in some small mammals of arctic Norway. Jour. Animal Ecol., Cambridge, vol. 24, no. 2, pp. 412–425. November, 1955.

HUGHES, J. C. S. My first bushcow. Nigerian Field (Jour. Nigerian Field Soc.), vol. 20, no. 4, pp. 182–184. October, 1955.

HUSSON, A. M., AND L. B. HOLTHUIS. The dates of publication of "Verhandelingen over de Natuurlijke Geschiedenis der Nederlandsche Overzeesche Bezittingen" edited by C. J. Temminck. Zool. Mededel. Rijksmus. Nat. Hist. Leiden, vol. 34, no. 2, pp. 17–24. September 28, 1955.

HUSSON, A. M. Tabel voor het determineren van de landzoogdieren van Nederlands Nieuw-Guinea. Zool. Bijdr. Rijksmus. Nat. Hist. Leiden, no. 1, pp. 1–35, illus. November 7, 1955.

IANOVSKI, N. M. New genus of Embolotheriinae from the Paleogene of Mongolia. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 55, pp. 5–43, illus. 1954. (New: *Protembolotherium, P. efremovi*.)

IMAIZUMI, YOSHINORI. Systematic notes on the Korean and Japanese bats of *Pipistrellus savii* group. Bull. Nat. Sci. Mus., Tokyo, vol. 2, no. 2, pp. 52–63, pls. 8–9. September, 1955. (New: *P. s. coreensis*.)

INGLES, ELIZABETH. Mystery mice of the sagebrush. Audubon Mag., New York, vol. 57, no. 5, pp. 206–207, 238, illus. October, 1955. (*Onychomys, Microdipodops*)

IVERSEN, BJØRGULV. Whaling activity in Iceland. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), vol. 44, no. 10, pp. 598–606, illus. October, 1955.

JACKSON, HARTLEY H. T. The Wisconsin puma. Proc. Biol. Soc. Washington, vol. 68, pp. 149–150. October 31, 1955. (New: *Felis concolor schorgeri*.)

JACKSON, W. T. That fighting fury, the bushbuck. African Wild Life, Johannesburg, vol. 9, no. 4, pp. 335–338, illus. December, 1955.

JANOSSY, D. Ritkább emlösök (*Sicista, Apodemus, Asinus*) a dorogi es mariaremetei kesöi pleisztocenböl. Földtani Közlony, Budapest, vol. 83, pp. 419–436, illus. 1953.

JENSEN, WALLACE, AND W. LESLIE ROBINETTE. A high reproductive rate for Rocky Mountain mule deer (*Odocoileus h. hemionus*). Jour. Wildlife Management, vol. 19, no. 4, p. 503. October, 1955.

JOHNSON, DAVID H. The incredible kangaroo. Nat. Geogr. Mag., Washington, vol. 108, no. 4, pp. 487–500, illus. October, 1955.

JOHNSON, DAVID H., AND J. KNOX JONES, JR. Three new rodents of the genera Micromys and Apodemus from Korea. Proc. Biol. Soc. Washington, vol. 68, pp. 167–174. December 31, 1955. (New: *Micromys minutus hertigi, Apodemus agrarius pallescens, A. a. chejuensis*.)

JOHNSON, DAVID H., AND J. KNOX JONES, JR. A new chipmunk from Korea. Proc. Biol. Soc. Washington, vol. 68, pp. 175–176. December 31, 1955. (New: *Eutamias sibiricus barberi*.)

JOHNSTON, C. STUART, AND D. E. SAVAGE. A survey of various late Cenozoic vertebrate faunas of the Panhandle of Texas, Part I. Introduction, preliminary faunal lists. Univ. California Publ. Geol. Sci., vol. 31, no. 2, pp. 27–50, illus. October, 1955.

JONES, J. KNOX, JR., AND DAVID H. JOHNSON. A new reed vole, genus Microtus, from central Korea. Proc. Biol. Soc. Washington, vol. 68, pp. 193–196. December 31, 1955. (New: *M. fortis uliginosus*.)

JONSGÅRD, ÅGE. Development of the modern Norwegian small whale industry. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), vol. 44, no. 12, pp. 697–718, illus. December, 1955.

KELLOGG, REMINGTON. Three Miocene porpoises from the Calvert Cliffs, Maryland. Proc. U. S. Nat. Mus., vol. 105, no. 3354, pp. 101–154, pls. 21. December 14, 1955. (New: *Lophocetus pappus, Pelodelphis, P. gracilis*.)

KHAVESON, Y. I. Tertiary camels of the Eastern Hemisphere (genus Paracamelus). Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 47, pp. 101–162, illus. 1954.

KILHAM, LAWRENCE, AND CARLTON M. HERMAN. Severe infestation of blow flies in a raccoon. Jour. Wildlife Management, vol. 19, no. 4, p. 499. October, 1955.

KIRKPATRICK, CHARLES M. The testis of the fox squirrel in relation to age and seasons. Amer. Jour. Anat., vol. 97, no. 2, pp. 229–256. illus. September, 1955.

KIRKPATRICK, CHARLES M., DONALD E. STULLKEN, AND ROBERT D. JONES, JR. Notes on captive sea otters. Arctic, Ottawa, vol. 8, no. 1, pp. 46–59, illus. Winter, 1955.

KIRPICHNIKOV, A. A. Two new genera of dolphins from the Sarmation of the U.S.S.R. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 47, pp. 181–190, illus. 1954. (New: *Leptodelphis, L. stavropolitanus; Sarmatodelphis, S. moldavicus.*)

KOSKIMIES, JUKKA. Ultimate causes of cyclic fluctuations in numbers in animal populations. Papers on Game Research, Finnish Game Commission, vol. 15, pp. 29. 1955.

KRATOCHVIL, J., AND B. ROSICKY. Die sibirische Wühlmaus *Microtus oeconomus*, ein Eiszeitrelikt in der ČSR. Práce Brněnské Zakladny Ceskoslovenské Akad. Věd, vol. 27, no. 1, pp. 33–72. 1955. (in Czech with German summary)

KRISHNAMURTI, M. The position of cattle in India. Tropical Agric., London, vol. 32, no. 4, pp. 278–289. October, 1955.

LARSON, CEDRIC. Scrimshaw: Art of the whale hunters. Think, International Business Machines Corp., New York, vol. 21, no. 11, pp. 14–15, illus. November, 1955.

LEHMANN, ALFRED. Einige Bermerkungen zur Robbendressur. Zool. Garten, Leipzig, vol. 22, no. 1, pp. 47–56, illus. 1955.

LEHMANN, ERNST VON. Die Säugetiere aus Fukien (SO-China) im Museum A. Koenig, Bonn. Bonner Zool. Beiträge, vol. 6, nos. 3–4, pp. 147–170. December, 1955.

LEHMANN, ERNST V. Neue Säugetierrassen aus Sudwestafrika. Bonner Zool. Beiträge, vol. 6, nos. 3–4, pp. 171–172. December, 1955. (New: *Elephantulus intufi omahekensis, Rattus namaquensis longicaudatus, Petromyscus collinus kurzi, Desmodillus auricularis hoeschi, D. a. wolfi, Tatera afra kaokensis.*)

LENTFER, JACK W.A two-year study of the Rocky Mountain goat in the Crazy Mountains, Montana. Jour. Wildlife Management, vol. 19, no. 4, pp. 417–429, illus. October, 1955.

LEOPOLD, A. S. Too many deer. Scientific American, New York, vol. 193, no. 5, pp. 101–108. November, 1955.

LIE, GUNNAR. Superfetation in cats, and some observations on the pubertal age of female cats. Nytt Mag. Zool., vol. 3, pp. 66–69. 1955.

LIEDERMAN, M. B. Size variations in Tasmanian rabbits. Pap. & Proc. Roy. Soc. Tasmania, Hobart, vol. 89, pp. 125–130, illus. 1955.

LUETH, FRANCIS X. Why shoot spikes? Alabama Conservation, vol. 27, no. 3, pp. 12–13, 19, 26, illus. November-December, 1955. (White-tailed deer)

MABERLY, C. T. ASTLEY. Some giraffe notes and problems. African Life, Johannesburg, vol. 9, no. 4, pp. 330–332, illus. December, 1955.

MARTIN, EDWIN P., AND GEORGE F. STERNBERG. A swift fox, Vulpes velox velox (Say), from western Kansas. Trans. Kansas Acad. Sci., vol. 58, no. 3, pp. 345–346. September 24, 1955.

MARTIN, FRANK R. Red fox food habits in the vicinity of a vulnerable captive goose flock. Jour. Wildlife Management, vol. 19, no. 4, pp. 496–497. October, 1955.

MATTHEWS, L. HARRISON. The migration of mammals. Ann. Rept. Smithsonian Inst., Washington, 1954, publ. 4199, pp. 277–284, illus. 1955.

MATTHEY, ROBERT. Les chromosomes de *Galago senegalensis* Geoffroy (*Prosimii—Lorisidae —Galaginae*). Rev. Suisse Zool., Geneva, vol. 62, pp. 190–197. November, 1955.

MCINTOSH, WILLIAM B. The applicability of covariance analysis for comparison of body and skeletal measurements between two races of the deermouse, *Peromyscus maniculatus*. Contrib. Lab. Vert. Biol., Univ. Michigan, no. 72, pp. 54. September, 1955.

MENDEZ-AROCHA, JOSÉ L. El nombre científico de los venados caramudos o caramerudos venezolanos. Mem. Soc. Ciencias Nat. La Salle, Caracas, vol. 15, no. 41, pp. 133–136. May-August, 1955. (*Odocoileus cariacou* distinct from *O. virginianus.*)

MIKULA, EDWARD J. An efficient handling crate for whitetail deer. Jour. Wildlife Management, vol. 19, no. 4, pp. 501–502, illus. October, 1955.

MILLER, RICHARD S. Activity rhythms in the wood mouse, *Apodemus* sylvaticus and the bank vole, *Clethrionomys glareolus*. Proc. Zool. Soc. London, vol. 125, pts. 3–4, pp. 505–519, illus. November 23, 1955.

MOSSMAN, H. W., ROGER A. HOFFMAN, AND CHARLES M. KIRKPATRICK. The accessory genital glands of male gray and fox squirrels correlated with age and reproductive cycles. Amer. Jour. Anat., vol. 97, no. 2, pp. 257–301, illus. September, 1955.

MOSTACHFI, PEZECHGPOUR. Dimorphisme sexuel des glandes sous-maxillaires du rat. Ses relations avec la thyroïde et l'action goitrigène du soja. Rev. Suisse Zool., vol. 62, no. 35, pp. 539–583. September, 1955.

MYERS, K. Coprophagy in the European rabbit (*Oryctolagus cuniculus*) in Australia. Australian Jour. Zool., Melbourne, vol. 3, no. 3, pp. 336–345, illus. October, 1955.

NARDONE, R. M., C. G. WILBER, AND X. J. MUSACCHIA. Electrocardiogram of opossum during exposure to cold. Amer. Jour. Physiol., vol. 181, no. 2, pp. 325–329. May, 1955.

NOLTE, ANGELA. Field observations on the daily routine and social behaviour of common Indian monkeys, with special reference to the bonnet monkey (*Macaca radiata* Geoffroy). Jour. Bombay Nat. Hist. Soc., vol. 53, no. 2, pp. 177–184. December, 1955.

OAKLEY, KENNETH P., AND J. S. WEINER. Piltdown man. Amer. Scientist, vol. 43, no. 4, pp. 573–583, illus. October, 1955.

OLALLA, A. M. Notas biologicas sôbre a pacarana "Dinomys branickii Peters". Fauna, São Paulo, Brazil, vol. 14, no. 3, pp. 32–49, illus. March, 1955.

PELIKÁN, JAROSLAV. Studie über die Standorte von *Microtus arvalis* Pall. Práce Brněvské Zakladny Ceskoslovenské Akad. Věd, vol. 27, no. 1, pp. 1–32. 1955. (In Czech with German summary)

PETTER, F. Contribution a l'etude de *Meriones vinogradovi* Heptner 1931 (Rongeurs, Gerbillidae). Mammalia, Paris, vol. 19, no. 3, pp. 391–398, illus. September, 1955.

PIECHOCKI, RUDOLF. Beobachtungen an Zwergmäusen, *Micromys minutus*, Pall., in Gefangenschaft. Zool. Garten, Leipzig, vol. 22, no. 1, pp. 11–29, illus. 1955.

PILTERS, H. Observations éthologiques sur les tylopodes. Mammalia, Paris, vol. 19, no. 3, pp. 399–415, illus. September, 1955.

PIRLOT, P. L. Variabilité intra-générique chez un rongeur africian (Tatera Lataste). Ann. Mus. Roy. Congo Belge, Tervuren, vol. 39, pp. 66, illus. 1955.

PONSE, KITTY. La fonction androgène de l'ovaire chez l'animal. III[e] Réunion des Endocrinologists de langue française, Brussels, 1955, pp. 89–138. 1955.

POURNELLE, GEORGE H. Tasmanian envoys. Zoonooz, Zool. Soc. San Diego, vol. 28, no. 12, pp. 3–4, illus. December, 1955. (Tasmanian devil)

QUINN, JAMES H. Miocene Equidae of the Texas Gulf Coastal Plain. Univ. Texas Publ., no. 5516, pp. 1–102, illus. November, 1955. (New: *Protohippus vetus, Pliohippus circulus, Callippus anatinus, C. optimus, Astrohippus curtivallis, Griphippus, Dinohippus, D. subvenus, Hippotigris sellardsi, H. clarendonensis, H. parastylus, Eoequus, E. wilsoni, Equus laparensis*. New tribes: Calippini, Equini, Hipparionini.)

RENSENBRINK, H. P. Jonge panters. Artis, Amsterdam, vol. 1, no. 3, pp. 54–58, illus. October, 1955.

REVENTLOW, AXEL. Nördliche See-Elefanten (*Mirounga angustirostris*) im Zoologischen Garten Kopenhagen. Zool. Garten, Leipzig, vol. 22, no. 1, pp. 73–76, illus. 1955.

RYDER, RICHARD A. Fish predation by the otter in Michigan. Jour. Wildlife Management, vol. 19, no. 4, pp. 497–498. October, 1955.

SAUNDERS, JACK K., JR. Food habits and range use of the Rocky Mountain goat in the Crazy Mountains, Montana. Jour. Wildlife Management, vol. 19, no. 4, pp. 429–437, illus. October, 1955.

SAVAGE, DONALD E. A survey of various late Cenozoic vertebrate faunas of the Panhandle

of Texas, Part II. Proboscidea. Univ. California Publ. Geol. Sci., vol. 31, no. 3, pp. 51–74, illus. October, 1955.

SCHÄFER, ERNST. Mamíferos venezolanos. Revista Shell, Caracas, vol. 4, no. 17, pp. 36–40, illus. December, 1955.

SCHOFIELD, RAYMOND D. Analysis of muskrat age determination methods and their application in Michigan. Jour. Wildlife Management, vol. 19, no. 4, pp. 463–466. October, 1955.

SCHOLANDER, P. F., AND W. E. SCHEVILL. Counter-current vascular heat exchange in the fins of whales. Jour. Applied Physiol., vol. 8, no. 3, pp. 279–282. November, 1955.

SCHULTZ, VINCENT. The effects of a severe snow and ice storm on game populations in Tennessee. Jour. Tennessee Acad. Sci., vol. 29, no. 1, pp. 24–35. January, 1954.

SCHULTZ, VINCENT. Status of the black bear in Tennessee. Jour. Tennessee Acad. Sci., vol. 30, no. 1, pp. 40–43. January, 1955.

SCHULTZ, VINCENT. Status of the coyote and related forms in Tennessee. Jour. Tennessee Acad. Sci., vol. 30, no. 1, pp. 44–46. January, 1955.

SCHULTZ, VINCENT. Status of the white-tailed deer in Tennessee. Jour. Tennessee Acad. Sci., vol. 30, no. 1, pp. 66–75. January, 1955.

SEARS, H. S., AND L. G. BROWMAN. Quadruplets in mule deer. Anat. Record, vol. 122, no. 3, pp. 335–340. July, 1955.

SETZER, HENRY W. Two new jerboas from Egypt. Proc. Biol. Soc., Washington, vol. 68, pp. 183–184. December 31, 1955. (New: *Jaculus jaculus elbaensis, J. j. favillus.*)

SIIVONEN, LAURI, AND JUKKA KOSKIMIES. Population fluctuations and the lunar cycle. Papers on Game Research, Helsinki, no. 14, pp. 1–22, illus. 1955.

SOKOLOV, I. I. On the discovery of remains of "Pologs" (Bovidae, Mammalia) in Lower Miocene deposits of Western Gobi. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 41, pp. 155–158, illus. 1952. (New: *Gobiocerus, G. mongolicus.*)

SOUTHERN, H. N. Nocturnal animals. Sci. American, New York, vol. 193, no. 4, pp. 88–98, illus. October, 1955.

SOUTHWICK, C. A. Regulatory mechanisms of house mouse populations: social behavior affecting litter survival. Ecology, vol. 36, no. 4, pp. 627–634, illus. October, 1955.

STEPHEN-HASSARD, Q. M. Beastly dentistry. Zoonooz, Zool. Soc. San Diego, vol. 28, no. 12, pp. 5–7, illus. December, 1955. (Animal teeth)

STEVEN, D. M. Small mammal communities of the north Scandinavian birch forest. Jour. Animal Ecol., Cambridge, vol. 24, no. 2, pp. 403–411, illus. November, 1955.

STUEWER, F. W. Fox squirrel sketches. Michigan Conserv., Lansing, vol. 24, no. 5, pp. 12–14, illus. October, 1955.

TAYLOR, (MRS.) S. Breeding dwarf mongooses. Zoo Life, London, vol. 10, no. 3, pp. 70–72, illus. Autumn, 1955.

THOMPSON, DANIEL Q. The 1953 lemming emigration at Point Barrow, Alaska. Arctic, Ottawa, vol. 8, no. 1, pp. 37–45, illus. Winter, 1955.

TIEMEIER, OTTO W. Winter foods of Kansas coyotes. Trans. Kansas Acad. Sci., vol. 58, no. 2, pp. 196–207. June 21, 1955.

TRINDADE, ALVARO EMERY. Blood counting of normal and mixomatous rabbits. Mem. Inst. Oswaldo Cruz, Rio de Janeiro, vol. 52, no. 2, pp. 397–403. June, 1954. (In Portuguese, with English translation.)

TROFIMOV, B. A. New entelodontids from Mongolia and Kazakhstan. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 41, pp. 144–154, illus. 1952. (New: *Entelodon diconodon; Brachyodon, B. gobiensis.*)

TROFIMOV, B. A. On the genus Pseudictops—an unusual insectivore from lower Tertiary deposits in Mongolia. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 41, pp. 7–12, illus. 1952. (New: *Pseudictops arilophiodon.*)

TROFIMOV, B. A. Fossil pigs of the genus Microstonyx. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 47, pp. 61–99, illus. 1954.

TROUGHTON, ELLIS. The koala. Australian Mus. Mag., Sydney, vol. 11, no. 12, pp. 396–401, illus. December, 1955.

TUREK, A., AND J. VOLF. Pavilon opic a jeho obyvatelé v pražském zoo. Ziva, Prague, vol. 41, no. 3, pp. 221–227, illus. 1955.

TWENTE, J. W., JR. Some aspects of habitat selection and other behavior of cavern-dwelling bats. Ecology, Durham, vol. 36, no. 4, pp. 706–732, illus. October, 1955.

UHLIG, HANS G. The determination of age of nestling and sub-adult gray squirrels in West Virginia. Jour. Wildlife Management, vol. 19, no. 4, pp. 479–483. October, 1955.

ULLRICH, WOLFGANG. Bemerkenswerte Aufnahmen eines jungen Sumatra-Nashorns (*Dicerorhinus sumatrensis* Cuv.). Zool. Garten, Leipzig, vol. 22, no. 1, pp. 29–33, illus. 1955.

VENABLES, U. M., AND L. S. V. VENABLES. Observations on a breeding colony of the seal *Phoca vitulina* in Shetland. Proc. Zool. Soc. London, vol. 125, pts. 3–4, pp. 521–532, illus. November 23, 1955.

VIEIRA, C. Roedores e lagomorfos do Estado de São Paulo. Arquivos Zool., São Paulo, vol. 8, pp. 129–166, illus. 1955.

VIEIRA, C. Sobre uma coleção de mamiferos do Estado de Alagoas. Arquivos Zool., São Paulo, vol. 8, pp. 209–223. 1955.

VIEIRA, C. DA CUNHA. Lista remissiva dos mamiferos do Brasil. Arquivos Zool., São Paulo, vol. 8, pp. 341–464. 1955.

VINOGRADOV, B. S., AND P. P. GAMBARYAN. Oligocene cylindrodonts of Mongolia and Kazakhstan (Cylindrodontidae, Glires, Mammalia). Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 41, pp. 13–42, illus. 1952. (New: *Ardynomys*(?) *kazachstanicus*, *Pseudotsaganomys*, *P. turgaicus*, *P. mongolicus*.)

VOGE, MARIETTA, AND HOWARD A. BERN. Cecal villi in Dicrostonyx torquatus (Rodentia: Microtinae). Anat. Record, vol. 123, no. 1, pp. 125–129. September, 1955.

WEIR, J. A. Male influence on sex ratio of offspring in high and low olood-pH lines of mice. Jour. Heredity, vol. 46, no. 6, pp. 277–283. December, 1955.

WENZEL, DUANE G. An inexpensive mouse cage. Trans. Kansas Acad. Sci., vol. 58, no. 3, pp. 408–410. September 24, 1955.

WOOD, ALBERT E. Comments on the classification of rodents. Breviora Mus. Comp. Zool., Cambridge, no. 41, pp. 1–9. December 17, 1954.

WOOD, ALBERT E. Rodents from the Lower Oliogocene Yoder Formation of Wyoming. Jour. Paleontol., vol. 29, no. 3, pp. 519–524. May, 1955. (New: *Yoderimys*, *Y. bumpi;* subfamily Yoderimyinae.)

YANOVSKAYA, N. M. A new deer from the Middle Pliocene of Moldavia. Proc. Paleo. Inst., Acad. Sci. U.S.S.R., vol. 47, pp. 163–171, illus. 1954. (New: *Cervus* (*Rusa*) *moldavicus*.)

ZUH-MING, DIEN. A brief account of the Formosan flying squirrels. Quart. Jour. Taiwan Mus., Taipei, vol. 8, no. 3, pp. 203–206. September, 1955.

COMMENTS AND NEWS

ADDENDA

With the interest and help of Dr. W. E. Schevill, Woods Hole Oceanographic Institution, and Dr. D. E. Sergeant, Fisheries Research Board of Canada, the blackfish reported on in the August, 1955, issue of this journal ("Observations on young blackfish, *Globicephala*", Jour. Mamm. 36: 424–429) have been identified as *Globicephala melaena* (Traill) on the basis of skull characters, recently made available by the completion of cleaning of the skeletal material.—ANDREW STARRETT AND PRISCILLA STARRETT, *Museum of Zoology, University of Michigan, Ann Arbor.*

REACTIVATION OF THE NORTH AMERICAN CENSUS OF SMALL MAMMALS (NACSM)

The NACSM is a cooperative program whose basic operation is the determination of relative densities by the utilization of a standardized sampling procedure. This consists of a trap line of 20 stations, 3 traps at a station run for 3 consecutive days. Between 1948 and 1955 several thousand such determinations of density have been made. It was the original intent to distribute annual reports of complete details of each census to each cooperator. This was done for 1948, 1949, and 1950. After considerable delay arrangements have been completed for continuing this practice. The 1951 annual report is now available for distribution. Annual reports for 1952–55 will be distributed upon completion of editing and printing. This program has assurance of continuance through 1960 by which time many comparative studies may be made of the accumulated data by any of the cooperators who desire to use it.

In addition to the participating cooperators the NACSM program is coordinated by an advisory committee: David E. Davis, *Chairman*, Johns Hopkins University, 615 N. Wolfe Street, Baltimore 5, Maryland; John B. Calhoun, *Editor*, 2N310, Building 10, National Institutes of Health, Bethesda 14, Maryland; J. E. Moore, *Region 1* (Canada), Department of Zoology, University of Alberta, Edmonton, Alberta; Wm. L. Webb, *Region 2* (Northeastern U. S.: Wis., Mich., Ill., Ind., Ohio, N. Y., Pa., N. J., Mass., Conn., Vt., N. H., Me., R. I.), New York State College of Forestry, Syracuse 10, New York; Eugene P. Odum, *Region 3* (Southeastern U. S.: W. Va., Md., Del., Va., Tenn., N. C., S. C., Ga., Fla., Ala., Miss., La.), Department of Zoology, University of Georgia, Athens, Georgia; Sydney Anderson, *Region 4* (Central Plains States: N. D., S. D., Minn., Neb., Ia., Kan., Mo., Okla., Ark., Tex.), Museum of Natural History, University of Kansas, Lawrence, Kansas; Reed W. Fautin, *Region 5* (Rocky Mt. States: Mont., Idaho, Nev., Wyo., Utah, Colo., Ariz., N. M.), Dept. of Zoology and Physiology, University of Wyoming, Laramie, Wyoming; Daniel Brant, *Region 6* (Pacific Coast: Alaska ,Wash., Ore., Calif.), Division of Natural Sciences, Humboldt State College, Arcata, California.

Individuals whose program of research includes determinations of densities of small mammals may secure a brochure concerning the program from their regional representative on the committee. Each of these representatives has had considerable experience with the sampling procedure, and will be glad to discuss related problems with prospective cooperators.—David E. Davis.

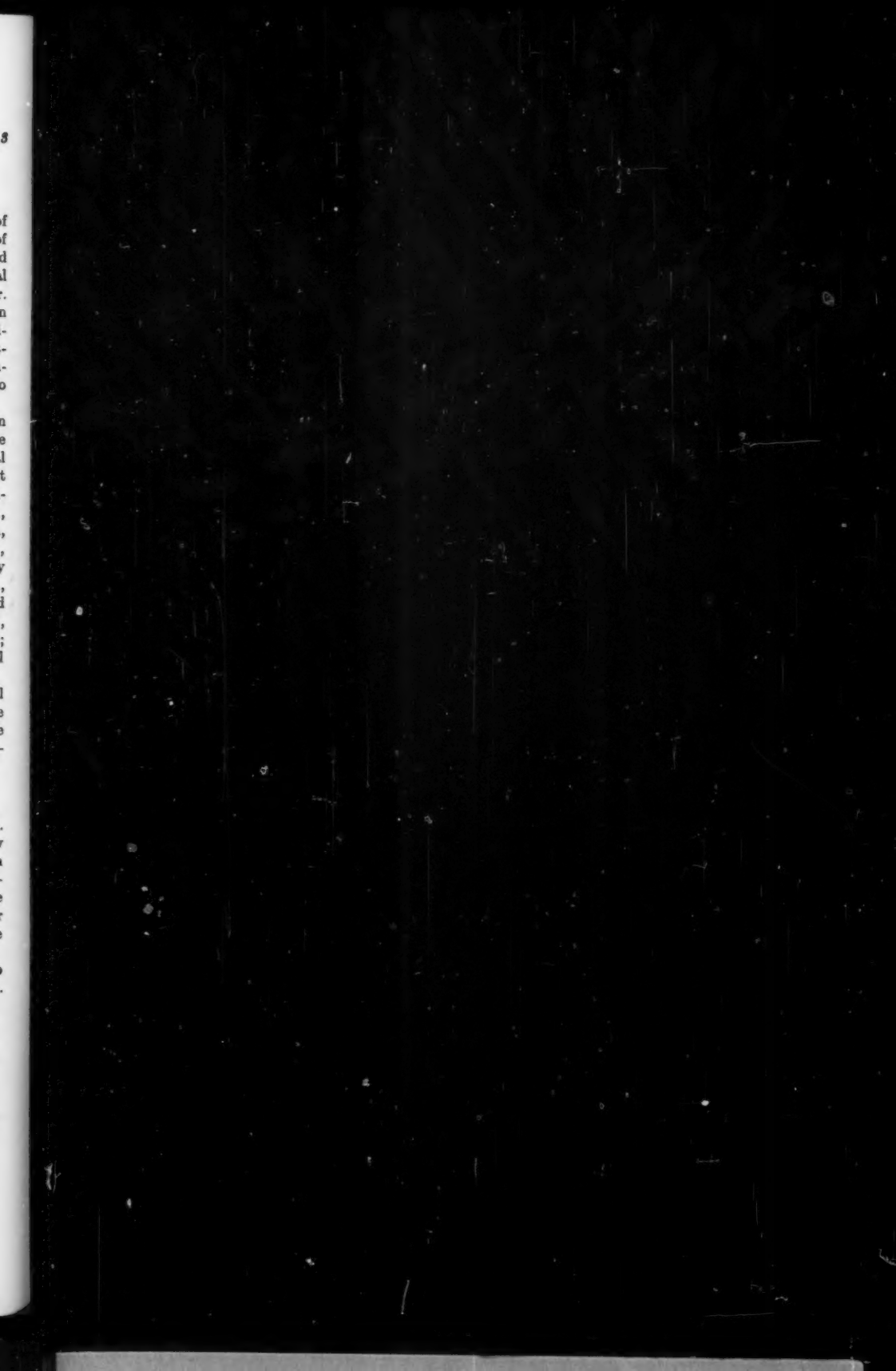
NEW EDITOR

The completion of this volume (37) in November will end my four-year-period as Editor. As the Journal grows, the task of editing becomes more arduous. Authors can help the new Editor, Dr. Richard H. Manville, by submitting only polished manuscripts that conform fully to Journal requirements. I sincerely hope you will extend to him the same understanding cooperation that I have experienced during my term as Editor. In this way the Journal of Mammalogy will continue to be the leading medium for the publication of your research findings. I express my thanks at this time for the unfailing assistance given to me by my editorial committee.

Manuscripts for publication, books for review, and special notices should now be sent to Dr. Richard H. Manville, 151 Ossining Rd. Pleasantville, New York.—W. Robert Eadie.

DATE OF ISSUE OF PREVIOUS NUMBER

Journal of Mammalogy, Vol. 37, No. 2, was mailed June 9, 1956



SALE

Back Numbers of
JOURNAL OF MAMMALOGY

Vol. 1, no. 5, each	$2.50	Vol. 20, no. 3, each	$2.00
Vol. 3, no. 1, Lithoprinted	2.00	Vols. 22–26, each	5.00
Vol. 4	6.00	Vol. 27, nos. 2, 3, 4, each	1.25
Vol. 6	6.00	Vol. 28	5.00
Vols. 7–19, each	5.00	Vol. 29, nos. 3, 4, each	1.25

Vols. 30–33 ..... $5.00 each

A discount of *20 per cent* is allowed members in good standing.

Prices are subject to change without notice; orders will be filled only as copies are available.

INDEX TO JOURNAL OF MAMMALOGY

The index to the first 20 volumes, 1919–1939 inclusive, of this Journal is still available. Paper cover, $2.50; cloth, $3.50.

The ten-year index, 1940–1949, is now available. Paper cover, $3.25; cloth, $3.75.

RECENT LITERATURE AND MEMBERSHIP LIST,

REPRINTS FOR SALE

Reprints of the section on *Recent Literature* are for sale at 18¢ per number or 70¢ per volume. Supply available beginning with Volume 11 (1930)

Send orders for any of above to BRYAN P. GLASS, Corresponding Secretary, DEPARTMENT OF ZOOLOGY, OKLAHOMA A. AND M. COLLEGE, STILLWATER, OKLAHOMA, *but made payable to the American Society of Mammalogists.*

CONTENTS

PAGE

Observations of Captive and Wild Cetaceans *David H. Brown and Kenneth S. Norris* 311
Body Temperature in the Northern Fur Seal, *Callorhinus ursinus*
George A. Bartholomew and Ford Wilke 327
Observations of Wolves Hunting Caribou *Lois Crisler* 337
Gray Fox Reproduction, Denning, Range, and Weights in Alabama *Edward G. Sullivan* 346
Preliminary Studies of the Kit Fox in Utah *Harold J. Egoscue* 351
Behavior of a Population of Forest Mice when Subjected to Poison *Lloyd Tevis, Jr.* 358
A Five-year Change in an Assemblage of Wood Rat Houses
Jean M. Linsdale and Lloyd Tevis, Jr. 371
Infrared Emissivities of some Arctic Fauna *H. T. Hammel* 375
The Relation of Coloration in Mammals to Low Temperature *Arthur Svihla* 378
Ossification Centers and Skeletal Development in the Postnatal Virginia Opossum
Carlita L. Nesslinger 382
Mammals of the Thousand Islands Region, New York *William E. Werner, Jr.* 395
Notes on the Mammals of Jackson County, Indiana
Russell E. Mumford and Charles O. Handley, Jr. 407
Synaptomys cooperi in Kentucky, with Description of a New Subspecies
Roger W. Barbour 413
Gerbils from Iraq, with Description of a New Gerbil *David L. Harrison* 417
On Two Mounted Skeletons of *Megalocnus rodens* *Carlos de Paula Couto* 423
General Notes 427

Notes and Blood Data on some Small Mammals of Durham County, North Carolina, *Charles W. Foreman*; A Protective Device for Reducing Trap Disturbance, *Raymond H. Brand*; Distributional Records of the Opossum in Ontario, *Randolph L. Peterson and S. C. Downing*; The Shrew *Sorex dispar* in Virginia, *Charles O. Handley, Jr.*; *Sorex merriami* and *Microtus mexicanus* in Colorado, *Hugo G. Rodeck and Sydney Anderson*; New Records of *Sorex merriami* for Eastern Washington, *George E. Hudson and Marion Bacon*; A Record of *Microsorex hoyi* from Kentucky, *Roger W. Barbour*; Reproduction of *Talpa europaea* in Suffolk, *Gillian K. Godfrey*; New Locality Records for Texas Bats, *R. B. Eads, G. C. Menzies and J. S. Wiseman*; Swimming Ability of the Little Brown Bat, *Bernard C. Patten, Jr. and Marie A. Patten*; *Myotis subulatus leibii* in Eastern New York, *Harold Schwager and Allen H. Benton*; Adjacent Roosts of *Eptesicus* and *Myotis*, *Elizabeth Smith and Woodrow Goodpaster*; Migration Records of the Red Bat, *Lasiurus borealis*, *John K. Terres*; Oceanic Records of *Lasionycteris noctivagans* and *Lasiurus borealis*, *John Mackiewicz and Richard H. Backus*; Daytime Roost of the Yellow Bat in Veracruz, *Rollin H. Baker and Robert W. Dickerman*; *Trypanosoma vespertilionis* from some Southern California Bats, *Ormand G. Mitchell*; Summer Weights of Raccoons in Northern Minnesota, *William H. Marshall*; An Early Record of the Wolverine in Western Nebraska, *Richard G. Beidleman*; Pituitary Removal in *Microtus* with Preservation of Skull, *Jay Stuart Haft*; Rearing of Lemmings at Fort Churchill, Manitoba, *J. S. Le Blanc*; The Young of *Neofiber alleni*, *W. J. Hamilton, Jr.*; Notes on Reproduction in the Kangaroo Rat, *Dipodomys*, *E. W. Pfeiffer*; Occurrence of *Perognathus fasciatus* in Utah, *C. Lynn Hayward and Merlin L. Killpack*; Pelage Color Changes in *Perognathus longimembris*, *C. Lynn Hayward*; Unusual Sex Behavior of a Male Porcupine, *Erethizon dorsatum epixanthum*, *Jeff Richard Spalsbury*; Extra Teeth in a Hare, *Mary R. Dawson*; Intentional Removal of a Disturbing Object by an Atlantic Bottlenose Dolphin, *David K. Caldwell*; An Unreported Specimen of the Whale, *Balaenoptera physalus*, *James V. A. Conkey*; *Pseudorca crassidens* Owen from Mediterranean Shores of Egypt, *Kamal Wassif*; Southern Right Whale in Australian Waters, *R. G. Chittleborough*; Mule Deer Record for Iowa, *Glen C. Sanderson*; Aggressive Behavior of Mule Deer toward Bobcat, *William R. Hanson*; The Appearance of a Moose Rutting Ground, *Howard E. Woodin*; Did the Pliocene Horse *Pliohippus* Eat Hackberries, *J. R. Macdonald and Sherrill Swenson*.

Reviews 459
Recent Literature 461
Comments and News 471